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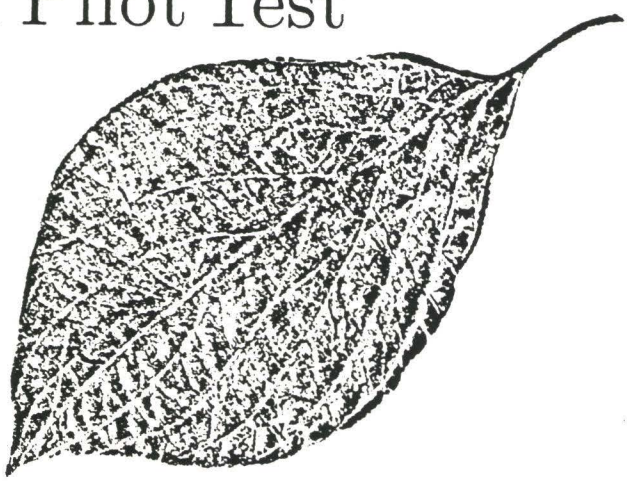
United States
Department of
Agriculture

Forest Service
Southern Region

Protection Report
R8-PR 24

Results of the 1992 Dogwood Anthracnose Impact Assessment and Pilot Test



in the Southeastern United States

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This publication reports pilot testing involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife–if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Results of the 1992 Dogwood Anthracnose Impact Assessment and Pilot Test in the Southeastern United States

(Includes 1989-91 Progress Report)

Protection Report R8-PR 24

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August 1993

Contents

Page

Contributors v

Background 1

Summary 7

Agencies That Participated in the Impact Assessment and Pilot Testing 9

Report Summaries 10

Individual Studies

Distribution of Dogwood Anthracnose in the Southeastern United States - December 1992 15

Dogwood Anthracnose Impact Assessment in the Southeast - 1992 24

A Preliminary Hazard Rating for Dogwood Anthracnose in the Southern Appalachians 35

Increased Dogwood Anthracnose Severity in Great Smoky Mountain National Park from 1988-1992 41

Factors Affecting Dogwood Anthracnose Severity in the Great Smoky Mountain National Park 46

Effectiveness of Cultural Techniques, with Emphasis on Fertilization, to Control Dogwood Anthracnose 53

Effect of Nitrogen and Phosphorus Fertilization on Dogwood Anthracnose Infection 57

Effect of Nitrogen Rate and pH on the Dogwood Anthracnose Fungus Development on Flowering Dogwoods (*Cornus florida*) 58

Effect of Application Intervals and Two Rates of Banner on Dogwood Anthracnose Severity 59

Evaluation of Fungicide Foliar Sprays and Different Schedules on Control of Dogwood Anthracnose 61

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Background

Dogwood anthracnose is a leaf and stem disease of flowering and Pacific dogwood, (*Cornus florida L.* and *C. nuttallii Audubon*) caused by *Discula destructiva* (6). Infection of Pacific dogwood has been reported from Washington, Oregon, Idaho, and British Columbia. In the Southeastern United States, the disease has been reported on flowering dogwood in Virginia, North and South Carolina, Tennessee, Georgia, Kentucky, and Alabama.

Infection of dogwoods is favored by cool, wet weather. Drought and winter injury weaken trees and may predispose trees to infection. Consecutive years of heavy infection have resulted in extensive mortality of both woodland and ornamental dogwoods. The origin of this disease is unknown, but it is suspected to have been introduced.

Dogwood Anthracnose was first reported in 1978. It was causing a widespread, rapid deterioration of flowering dogwood in New York and Connecticut. In 1983, Daughtrey and Hibben (2) reported a lower branch dieback disease with the same symptoms on flowering dogwood in New York, Connecticut, New Jersey, and Pennsylvania. They made observations on trees in Planting Fields Arboretum, Oyster Bay, Long Island, and a woodland site at the Brooklyn Botanic Garden Research Center in Ossining, NY. They reported the cause of the disease to be a species of *Discula sp.*, and that the reason for a sudden onset of anthracnose over part of the northeastern range and its coincidental outbreak on western flowering dogwood was unknown. They speculated that climatic changes may have been a factor and that the disease may have been introduced. Hudler proposed that droughts or sudden changes in the environment may have predisposed the trees to infection (3). In 1984, a survey of dogwood anthracnose was made in Catoctin Mountain National Park. Mielke and Langdon found that only 3 percent of the dogwoods were disease free, and that about one-third were dead (5). Schneeberger and Jackson repeated the survey in 1988 and found that 89 percent of the dogwoods were dead, that there was almost no regeneration, and that all remaining trees were diseased (7). Since that time a few trees have been identified in this area with possible resistance. They are being evaluated at this time.

Byther and Davidson described a similar disease on western flowering dogwoods in western Washington and named it "dogwood anthracnose." The disease was reported in Oregon, Idaho, and British Columbia in 1983 (1). The causal organism was reported to be *Discula sp.* Daughtrey and Hibben compared the symptoms, and signs, on the western flowering dogwood and the eastern flowering dogwood, and concluded that the same disease occurs in both area. It was at this time that the disease on eastern flowering dogwood was named "dogwood anthracnose" (2). In 1985, Mielke and Daughtrey wrote a pest alert designed to help assess the distribution and spread (4). By 1987 the disease had been reported in over 60 counties in 8 Northeastern States (Connecticut, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Virginia, and West Virginia). In the late 1970's and early 1980's there was considerable speculation as to whether dogwood anthracnose could successfully spread to the southeastern United States. In October of 1987, unusual numbers of dogwoods were reported dying on the Cohutta Ranger District on the Chattachoochee National Forest in northern Georgia. All of the symptoms matched those of dogwood anthracnose. Foresters estimated that the affected area covered about 30,000 acres of the Cohutta Wilderness. *Discula sp.*, the causal organism of dogwood anthracnose, was isolated from samples from the affected area.

The National Forest Supervisor and State Forester of Georgia were notified of the occurrence. Soon thereafter, Bob Zahner, a professor from Clemson University, reported an unusual problem with the dogwoods in Cashiers, NC. This area was checked and *Discula sp.* was found. In this case, the affected area was much larger than the 30,000 acres found in Georgia. The State Forester of North Carolina was notified, and a meeting of State and Federal personnel from the affected and adjacent States was held in Dillard, GA, in February 1988. This group became a dogwood anthracnose working group and agreed that the top priority was to assess the disease distribution. The Southern Region of the Forest Service distributed a southern version of the dogwood anthracnose pest alert.

By the second meeting of the working group in May of 1988, the disease had been found in Georgia, North Carolina, South Carolina, Tennessee, and Virginia. It was reported that the disease affected trees of all sizes and was more common in the mountains and cool, wet valleys. Six nurseries in North Carolina and one in South Carolina were reported to have diseased trees. Fungicide trails were started in Georgia and Tennessee, and a joint pilot-test proposal was prepared for submission to the Washington Office. Coleman Doggett, North Carolina Pest Control Forester proposed that permanent plots be established on a 15-minute grid to assess the current and future impacts. These plots were installed by State and Federal personnel in each of the respective States. In June of 1988, the fungus had been found in so many locations that the USDA Forest Service and the University of Georgia began to provide sample identification services. In September the working group developed a news release, but it was decided not to send the release until more information was collected. After this point, the information became known to the press and public. As a result, the news release was never issued. The National Park Service did distribute a news release from the Great Smoky Mountain National Park. Dogwood anthracnose and its impact received major media coverage.

At this point, a lot of work was being done, and the working group concept was good, but the process was reactive and information was not being managed to assist in the process. The public was getting scarce information from the press, and politicians were responding to the problem without knowing the whole story. A third meeting of the dogwood anthracnose working group was held in October 1988. By this time, a funding proposal had been submitted to the Washington Office for consideration. The disease had been identified in 49 counties in the South, and 60 permanent plots had been established to assess impact. Birds were discussed as possible vectors, and fungicide studies in Georgia and Tennessee had not produced positive results. Fungicides had been applied in the late summer. One important concern was the inability to inoculate trees under controlled conditions. A high priority was placed on this task. In November of 1988 the Great Smoky Mountain National Park, in cooperation with the University of Tennessee, completed a survey of the Park and found the disease was widespread.

In January of 1989, the Regional Forester for the Southern Region of the USDA Forest Service called a meeting of the Federal and State cooperators to discuss dogwood anthracnose. At this meeting, a list of priorities was developed for survey, impact assessment, and research, and a dogwood anthracnose steering committee headed up by the state forestry of Georgia was developed to help with the biological, political, and funding aspects of the problem.

In March 1989, eight national forests were surveyed to assess the distribution. At the same time, a greenhouse inoculation test was completed with positive results. Anderson, Knighten, and Dowsett found when seedling leaves were pretreated with an acid mist, fungus spores routinely produced infections on them. Results led to a controlled acid rain study where a positive correlation was established between simulated acid rain and infection in the greenhouse. Funding was approved for a pilot test of control techniques, and several studies were started by the USDA Forest Service, the University of Tennessee, University of Georgia, and the National Park Service.

In the spring of 1989, the media coverage picked up considerably. The story ran in dozens of newspapers and on radio and TV. CBS National News did a Saturday segment on the disease. Realizing the need to provide the best information possible to the public, the USDA Forest Service, the University of Georgia, and the State Forester of Georgia developed and published a booklet on how to manage dogwoods. To keep public officials informed, a briefing package was developed by the Forest Service. The package included a briefing paper and a list of people to be contacted. It was about this time that the correlation between simulated acid rain and dogwood anthracnose was released. Because of the interest in acid rain, major political problems arose as the information was released to the press. At this time, proposals for research and impact assessment were being submitted to the Washington Office. The Southeastern Forest Experiment Station assigned one person to work part-time on the disease in 1989. By this time, the disease had been found in 57 counties in 7 Southern States.

In September of 1989, the working group met again to discuss progress. Eighty-four counties were reported with diseased trees, and the impact plots showed the disease had increased from 1/2 million acres in 1988 to 2.2 million acres in 1989. The National Park Service announced that it would investigate mycological aspects of the problem. Forest Service research officials reported that they would be working on epidemiology.

In 1989, Kerry Britton of the Southeastern Forest Experiment Station was assigned full-time to work on dogwood anthracnose.

Forest Pest Management evaluated a forest stand that had a major component of dogwood near Asheville, NC. After about 3 years of infection, 42 percent of the dogwoods had died, the remainder were infected, and there was no regeneration. The disease was spreading rapidly, heavily impacting large areas.

By 1990 considerable information was accumulating. The acid rain study was repeated and showed the same result. It was noted that the fungus seemed to remain active and grow down the dogwood shoots in the winter. The disease was more common at high elevations and in cool, wet coves was able to spread over large areas very quickly (127 counties now had diseased trees), and the fungus preferred cool temperatures. Pilot-test data showed that the fungicides Benlate and Daconil were providing effective control and that other fungicides showed promise. Fertilization and mulching seemed to improve tree vigor, while not increasing the disease in the field. Other greenhouse and field tests were showing that phosphorus tended to increase and lime tended to decrease disease symptoms.

Nevertheless, we still knew very little about this complex problem. Early literature reported that there was no resistance in the native flowering dogwood populations, but people were noting some trees in the field that seemed to show resistance. Resistance became a high priority for research in 1990.

In the fall of 1990, the Southern Appalachian Man and Biosphere Cooperative, consisting of the U.S. Environmental Protection Agency, Forest Service, Park Service, Southeastern Forest Experiment Station, Fish and Wildlife Service, Department of Energy, Economic Development Administration, and the Tennessee Valley Authority, organized two dogwood anthracnose conferences. One was held in Knoxville, TN, and the other was held in Asheville, NC. These conferences consisted of representatives from Federal, State, and private concerns, and featured speakers from a number of these agencies. The program reflected a diversity of views held by various groups throughout the South. These meetings increased the awareness of and understanding of dogwood anthracnose, and helped define specific goals, such as effective information dissemination. A follow-up meeting was held in Roanoke, VA in 1991.

Forest Pest Management took the lead for maintaining incidence maps. Since there are so many mimicking symptoms, it was decided that for a county to be designated "affected," disease presence had to be confirmed in the laboratory. In 1990, the plot data were added to a Geographic Information System to generate maps displaying both severity and incidence. By 1991, the disease had been confirmed in 163 counties in 7 Southeastern States.

In January 1991, another working group meeting was held. Members reported progress in all areas. Five hundred thousand copies of an updated version of "Growing and Maintaining Healthy Dogwoods" including revised control methods were published. Also in 1991, the fungus causing dogwood anthracnose was described as "*Discula Destructiva sp.* Nov." (6) and dogwood resistance screening was developed.

For impact assessment, some 210 permanent 10-tree dogwood plots had been established in North Carolina, South Carolina, Tennessee, Alabama, Virginia, Kentucky, and Georgia. These plots were selected in a random stratified sample on a 15-minute grid. Data showed that the disease increased dramatically (from about 1/2 million acres in 1988 to 9.6 million acres in 1991), and the severity in the permanent plots has increased. Obviously, the rapid increase in the area affected reflects discovery of stands infected for some time, in addition to actual yearly increases. However, from observation of infection in relatively large geographic areas, it is clear that there was a major increase in the disease incidence and impact in 1989, 1990, and 1991.

By 1992 the disease had spread to over 12.8 million acres (in 182 counties in 7 Southeastern States) and the dogwoods had been destroyed on selected sites over a large area of the Appalachian Mountain Chain. This was the most severe year for infection and damage since the disease was first found in the South. The disease was found for the first time in the Coastal Plain of VA. The long-term outlook for trees in the Piedmont and Coastal Plain is uncertain. A dogwood working group meeting was sponsored by VPI and held in West Virginia. The emphasis at the meeting changed from survey and impact to reporting research results. The list of 10 essential steps to maintain healthy dogwoods was revised at the meeting.

Since dogwood anthracnose was first found in the South in 1987 until the 1993 culmination of the impact assessment and pilot testing, the focus has been to determine the spread and impact over time, develop a hazard rating system, and produce the most up-to-date control strategies that were pilot tested under southern conditions.

This update presents the results of the 1992 impact assessment and pilot testing in the South.

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Summary

By December of 1992, dogwood anthracnose had been found in 182 counties in 7 Southern States. The increase over 1991 in number of affected counties was 11 percent. About 12.8 million acres are estimated to be affected, and mortality is increasing. Preliminary work on hazard rating systems seems to show a correlation between disease severity and elevation and aspect. The higher the elevation and the more northern, the more severe the damage to dogwoods. Work by the Great Smoky Mountain National Park has shown a relationship between disease occurrence and the proximity to water. University of Tennessee scientists have documented a major increase in disease occurrence in the Great Smoky Mountain National Park in 1992. They have also been able to demonstrate that increased sun exposure can reduce disease severity. The following recommended cultural control techniques (developed at the 1992 Dogwood Anthracnose Meeting) appear to be effective in reducing disease severity:

Ten Essential Steps for Maintaining Healthy Dogwoods

1. Know the disease and other problems commonly affecting dogwood.

2. Select healthy trees to plant. Avoid purchasing or moving diseased plants from one area to another. Purchase trees from a reputable, inspected nursery. Avoid transplanting trees from the "wild", especially from mountainous areas.

3. Select good planting sites to promote vigor and rapid drying of foliage. Avoid sites where prolonged high moisture situations prevail. (streams, lakes, ponds, watercourses, etc.)

4. Use proper planting techniques, replanting at the same soil level and preparing a large planting basin. "Plant a $10 tree in a $100. hole"

5. Use a maximum of 3-4 inch-deep mulch in an approximate (3 ft) radius around established trees, ensuring that mulch does not contact the trunk. Avoid using dogwood chips and leaves as mulch, since they may harbor disease organisms.

6. Prune and completely remove or destroy dead wood and leaves yearly. Avoid flush cuts! Prune epicormic growth (trunk or water sprouts) in late summer.

7. Water weekly in the morning during droughty periods. Caution: do not wet foliage.

8. Fertilize according to need based on soil analysis. Nutritional regimens that affect disease development are now being evaluated.

9. Use proper insecticides/fungicides where and when appropriate. Consult extension personnel for currently labeled pesticides. Fungicides should be applied at budswell (budbreak) and twice after as the leaves are expanding. Some spreader-stickers enhance wetting properties.

10. Avoid mechanical and chemical injuries to trees, especially lawnmower and string-trimmer wounds at the base.

As a result of the pilot testing, the pruning, watering, mulching, and fungicide recommendation have been modified. General pruning seems to be of little value, but removal of epicormic shoots helps to prevent stem infection. Watering during drought is effective, but the watering must be done in the morning and must not touch the foliage. Mulching helps by reducing moisture stress and reducing trunk wounding, but too much mulch (over 4 inches) can be detrimental. All fertilizer treatments resulted in reduced infection when compared with the check in low to moderate infection years. The treatments were effective in high infection years.

Different fungicides were sprayed at pre- and post-bud break. The registered fungicide Banner gave good control at a 4 week spray schedule. Domain FL is not registered for this purpose but also gave good control.

The final year of dogwood anthracnose impact assessments will be 1993 and reported next year. The distribution will continue beyond 1993.

Agencies That Participated in the Impact Assessment and Pilot Testing

USDA Forest Service - Forest Pest Management

Impact Assessment of the Southeast
Distribution of Dogwood Anthracnose
Cultural and Chemical Control Techniques
Fertilization

University of Georgia

Chemical and Cultural Control Techniques
Fertilization

Great Smoky Mountain National Park

Hazard Rating
Chemical and Cultural Control

State Foresters' Offices - Alabama, North Carolina, South Carolina, Virginia, Georgia, and Tennessee.

Distribution of Dogwood Anthracnose
Impact of Dogwood Anthracnose

North Carolina Department of Agriculture Extension Service

Fertilization

Report Summaries

The individual reports section contains the detailed reports for each of the assessments and pilot tests. A brief summary of each report follows:

Distribution of Dogwood Anthracnose in the Southeastern United States - December 1992

(Forest Pest Management)

Since dogwood anthracnose was found in the Southeastern United States, people from State, Federal, and private concerns have helped track its distribution. They report disease incidence and supply samples of diseased tissues to a laboratory. We add a county to the distribution map when diseased trees have been reported there and the presence of *Discula destructiva* (4) in diseased tissue is confirmed in a laboratory. By December 1992, 182 counties were classified in 7 Southern States as having infected trees.

Dogwood Anthracnose Impact Assessment in the Southeast - 1992

(Forest Pest Management)

Two hundred and ten permanent dogwood plots have been established in dogwood-anthracnose-affected counties in Virginia, North Carolina, South Carolina, Georgia, Kentucky, Tennessee, and Alabama. These plots were selected as a random stratified sample on a 15-minute latitude and longitude grid. The affected area in the Southeast was estimated at about 1/2 million acres in 1988 and 12.8 million acres in 1992. Mortality increased from 0 to 17 percent from 1988 to 1992, and the percent of severely damaged trees increased from 4 to 19 percent.

A Preliminary Hazard Rating for Dogwood Anthracnose in the Southern Appalachians

(Great Smoky Mountain National Park)

A preliminary hazard rating model has been developed for the Southern Appalachians. The model uses elevation, aspect and stream proximity to rate an area. In general, southern slopes are rated moderate risk if close to a stream, and low if further from the stream. Northerly slopes are moderate risk unless on or close to a stream, and then they are rated high risk. The model needs to be viewed with caution since it was developed during the early stages of an outbreak.

Increased Dogwood Anthracnose Severity in the Great Smoky Mountain National Park 1988-1992

(University of Tennessee and Great Smoky Mountain National Park)

Dogwood anthracnose incidence and severity have increased over the last 5 years. Epidemics were severe (> 25 foliage diseased) in 88 percent of plots in the Great Smoky Mountain National Park. Only 4 percent of plots contained all healthy trees. Reproduction potential of trees continued to decline in 1992, and 23 percent of trees surveyed had been killed by the disease.

Factors Affecting Dogwood Anthracnose Severity in the Great Smoky Mountain National Park

(University of Tennessee and Great Smoky National Park)

Dogwood anthracnose incidence and severity have increased over time in the Great Smoky Mountain National Park. Plots located within 50 m of water and plots with northern aspects had the highest disease incidence and severity. Disease incidence and severity were not correlated with elevation.

Effectiveness of Cultural Techniques, With Emphasis on Fertilization, to Control Dogwood Anthracnose

(Forest Pest Management)

Ornamental dogwood trees at the Bent Creek Experimental Forest in Asheville, NC were treated with different cultural treatments in 1990, 91, and 92. All treated trees were pruned, mulched, and sprayed for dogwood borers. Some trees received nitrogen, phosphorus, lime or a balanced fertilizer, or were watered during dry periods in 1990. The check trees did not receive any of the treatments. All trees were scored for disease symptoms on a score from 100 to 0, most severe to healthy, respectively. All fertilizer treatments were correlated with reduced disease symptoms in 1991 and 92. Nitrogen and phosphorus fertilization produced significantly lower disease ratings in 1992. There was no significant benefit from the treatments in 1992 under very severe disease pressure. The data suggest that cultural practices without fungicide treatments can reduce disease symptoms in low to moderate disease years but are not effective in severe disease years.

Effects of Nitrogen and Phosphorus Fertilization on Dogwood Anthracnose Infection

(University of Georgia)

Dogwood seedlings were planted at Georgia Mountain Station Blairsville, GA to evaluate the correlation between fertilization and dogwood anthracnose. The treatments were 1) no fertilization, 2) high nitrogen, 3) high phosphorous, and 4) high nitrogen and phosphorous. The percentage of leaves showing nerosis caused by dogwood anthracnose was very low, and there was no correlation between the treatment and subsequent symptom development.

Effects of Nitrogen Rate and pH on the Dogwood Anthracnose Fungus Development on Flowering Dogwoods (*Cornus florida*)

(North Carolina Department of Agriculture Extension Service and Forest Pest Management)

Three hundred and thirty 2-year-old budded flowering dogwoods, *Cornus florida*, plants were grown with 3 pH levels (5.5, 6.0, and 6.5) and fertilized weekly with three levels of nitrogen (50, 100, 200 ppm N). A high-phosphorous and a no fertilization treatment were also included. In 1991 the potted seedlings were located under infected dogwoods, and two artificial inoculations were made during the growing season. By the end of 1991 only one of the six replications had significant infection. In that replication there was a correlation with the nitrogen in the foliage and the percent disease severity. The plants were kept over winter and put back into the same field locations in the spring of 1992. When the leaves came out in the spring, there was a significant amount of dieback (averaged 40.7 percent) that took place during the winter. In 1992, the disease pressure was high enough to break down any treatment effect. The averaged percent of leaves

affected was 91.1 percent and the averaged percent severity was 55.7 percent. These data show that the fertilization levels used in this experiment were not able to reduce the impact of the dogwood anthracnose fungus, *Discula destructive*, given full shade, high inoculum pressure and favorable environmental conditions for the fungus.

Effect of Application Intervals and Two Rates of Banner on Dogwood Anthracnose Severity

(University of Tennessee)

Increasing the interval between applications of Banner 1.1 E (0.16 ml/l and 0.31 ml/l) from 2 weeks to 4 weeks did not significantly affect dogwood anthracnose disease severity. Based on these results, it may be possible to reduce the cost of this control measure and decrease the amount of pesticide released into the environment by increasing the time between applications.

Evaluation of Fungicide Foliar Sprays and Different Schedules on Control of Dogwood Anthracnose

(University of Georgia)

Foliar sprays of Daconil 2787 and Domain FL (467 ai) were tested using various spray schedules based upon pre- or post-bud break (flowers). Domain provided the best control of leaf infection. Daconil did not provide control under the severe disease conditions that developed in 1992.

Report # 93-1-30

Distribution of Dogwood Anthracnose in the Southeastern United States - December 1992 [1]

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Abstract

Since dogwood anthracnose was found in the Southeastern United States, people from State, Federal, and private concerns have helped track its distribution. They report disease incidence and supply samples of diseased tissue to a laboratory. A county is added to the distribution map, if a diseased tree is present and the presence of *Discula destructiva* (4) in diseased tissue is confirmed in a laboratory. By December 1992, 182 counties were classified in 7 Southern States as having infected trees.

Introduction

In the late 1970's a new disease (dogwood anthracnose) was found to be causing lower limb dieback and leaf lesions on flowering dogwoods (*Cornus florida*) in the Northeastern United States (2). In 1987 the disease, caused by the fungus *Discula destructiva*, (3) was found to be affecting 30,000 acres of Cohutta Wilderness in northern Georgia (1).

Since the disease was discovered in the Southeastern United States, Federal, State, and private concerns have helped track its distribution and spread. Forest Pest Management, Region 8, has coordinated the data and prepared distribution maps.

Methods

In 1987 and 1988, the States of Georgia, North Carolina, South Carolina, and Tennessee; the National Park Service; and the USDA Forest Service conducted dogwood anthracnose road surveys of the mountains and foothills in their respective areas. Symptomatic dogwoods were sampled and samples were sent to the Horticultural Research Laboratory at Cornell University for confirmation of the disease. A list was compiled of counties, by state, that had at least one infected flowering dogwood tree in which the presence of *Discula destructiva* was confirmed in a laboratory. Additional survey data after 1988 came from anyone who discovered an infected tree and had the presence of the fungus confirmed in a laboratory. The person or agency reporting a specific county has been recorded since the start of the mapping activities in 1987. Counties where all of the diseased trees have been removed are removed from or not added to the map. The maps are kept up to date with a Geographic Information System, maintained by the Regional Office in Atlanta, GA.

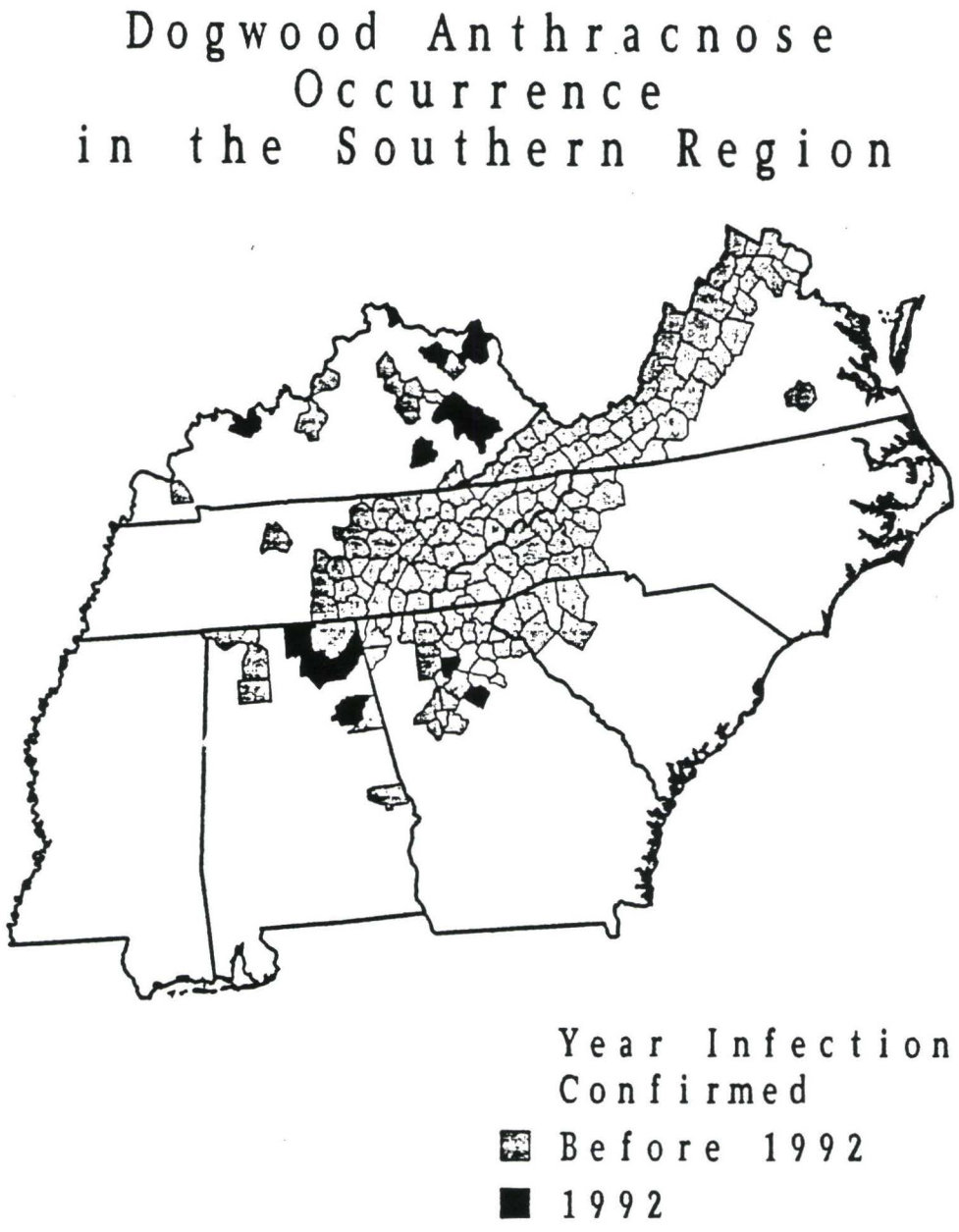
[1]A large number of people and agencies have contributed data to prepare this map. Figure 2 lists the contributors.

Results and Discussion

The list of affected counties in the Southeast has grown from 3 counties in 1987 to 182 in December 1992 (fig. 1 and table 1). In 1988 and 1989, the surveys and observations were detecting many areas where the disease had been around for some time. The surveys and observations in 1990 thru 1992 began to pick up primarily the disease spread into new areas. However, there was a concentrated effort to survey the western counties of Virginia in 1991 and eastern Kentucky in 1992 for the first time (table 1). The date a county was confirmed and the source of information are listed in table 2.

The disease is primarily found in the mountains, foothills, and upper Piedmont. Damage is most severe at high elevations and in cool moist areas at lower elevations.

Figure 1–Distribution of dogwood anthracnose in the Southeastern United States as of December 1992.[1]



[1]Map was prepared by Steve Holzman with the Geographic Information System in the Regional Office.

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Table 1--In each affected states, the number of counties, by year, confirmed in the laboratory to have at least one flowering dogwood tree infected with dogwood anthracnose

State	Year counties were added to the map						
	1987	1988	1989	1990	1991	1992	Total
Alabama	--	--	3	2	1	4	10
Georgia	1	6	11	9	1	2	30
Kentucky	--	--	1	4	5	11	21
North Carolina	--	13	5	6	--	--	24
South Carolina	--	5	1	--	--	--	6
Tennessee	--	15	14	8	8	--	45
Virginia	2	3	13	5	23	--	46
Total	3	42	48	34	38	17	182

* There was one county in Georgia and one in Virginia that was infected in 1991 but was not reported to us until 1992. Those two counties are included under 1991 in this table.

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found

State	County	Year	Source of information
North Carolina	Allegheny	1989	S. Spencer, R. Baldwin
	Ashe	90	D. Rogers
	Avery	88	J. Knighten
	Buncombe	88	B. Anderson, J. Knighten
	Burke	89	S. Dowsett
	Caldwell	90	D. Rogers
	Cherokee	88	S. Dowsett
	Clay	88	S. Dowsett
	Cleveland	88	S. Oak
	Graham	88	B. Anderson, S. Dowsett
	Haywood	88	M. Windham (Smokies)
	Henderson	88	D. Ledford
	Jackson	88	B. Anderson, J. Knighten, D. Ledford
	Macon	88	B. Anderson, J. Knighten
	Madison	89	S. Dowsett
	McDowell	88	J. Knighten
	Mitchell	90	J. Knighten, S. Dowsett
	Polk	89	S. Spencer
	Rutherford	90	J. Knighten
	Swain	88	M. Windham (Smokies)
	Transylvaina	88	B. Anderson, J. Knighten, D. Ledford
	Watauga	89	NCSU Plant Path. Clinic
	Wilkes	90	D. Rogers
	Yancey	90	Plot Data
Virginia	Albemarle	90	J. Stipes
	Allegheny	91	VA Dept. of Forestry
	Amherst	89	T. McCartney
	Augusta	89	J. Knighten
	Bath	89	T. McCartney
	Bedford	89	Blue Ridge Parkway
	Bland	91	VA Dept. of Forestry
	Botetourt	89	Blue Ridge Parkway
	Buchanan	91	VA Dept. of Forestry
	Carroll	89	Blue Ridge Parkway
	Clarke	87	Data from Plant Disease
	Craig	89	T. McCartney
	Dickenson	91	VA Dept. of Forestry
	Dinwiddie	91	VA Dept. of Forestry
	Fauquier	91	VA Dept. of Forestry
	Floyd	88	D. Anderson
	Franklin	89	Blue Ridge Parkway
	Fredrick	91	VA Dept. of Forestry
	Giles	89	T. McCartney

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found--Continued

State	County	Year	Source of Information
Virginia	Grayson	1989	Blue Ridge Parkway
	Greene	90	K. Langdon
	Highland	91	VA Dept. of Forestry
	Lancaster	91	J. Artman
	Lee	91	VA Dept. of Forestry
	Loudoun	86	Data from Plant Disease
	Montgomery	90	J. Stipes
	Nelson	88	J. Artman
	Northumberland	91	Todd Groh, J. Artman
	Page	91	VA Dept. of Forestry
	Patrick	89	Blue Ridge Parkway
	Prince William	91	J. Artman
	Pulaski	91	J. Rauschenberger
	Rappahannock	91	VA Dept. of Forestry
	Roanoke	89	Blue Ridge Parkway
	Rockbridge	88	Drake
	Rockingham	90	D. Rogers
	Russell	91	VA Dept. of Forestry
	Scott	91	VA Dept. of Forestry
	Shenandoah	91	J. Rauschenberger
	Smyth	91	VA Dept. of Forestry
	Tazewell	91	VA Dept. of Forestry
	Warren	90	S. Dowsett
	Washington	89	T. McCartney
	Wise	91	VA Dept. of Forestry
	Wythe	91	VA Dept. of Forestry
South Carolina	Anderson	89	A. Boone
	Greenville	88	A. Bonne
	Laurens	88	Plot Data
	Oconee	88	A. Boone
	Pickens	88	A. Boone
	Spartanburg	88	Plot Data
Alabama	Cleburne	91	N. Hess
	Jackson	90	B. Anderson, J. Knighten
	Lauderdale	89	N. Hess
	Lawrence	89	N. Hess
	Lee	90	W. Kelly
	Winston	89	N. Hess
Tennessee	Anderson	89	M. Windham
	Bledsoe	88	B. Kauffman
	Blount	89	M. Windham (Smokies)
	Bradley	91	B. Kauffman
	Campbell	90	B. Kauffman
	Cannon	91	B. Kauffman
	Carter	88	B. Kauffman
	Claiborne	91	B. Kauffman

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found--Continued

State	County	Year	Source of information
Tennessee	Cocke	1989	M. Windham
	Coffee	89	B. Kauffman
	Cumberland	88	B. Kauffman
	Davidson	88	B. Kauffman
	Fentress	90	B. Kauffman
	Franklin	89	B. Kauffman
	Greene	88	B. Kauffman
	Grundy	88	B. Kauffman
	Hamblen	91	B. Kauffman
	Hamilton	88	B. Kauffman
	Hancock	91	B. Kauffman
	Hawkins	90	B. Kauffman
	Jefferson	91	B. Kauffman
	Johnson	88	B. Kauffman
	Knox	89	M. Windham
	Loudon	89	B. Kauffman
	Marion	88	B. Kauffman
	McMinn	89	B. Kauffman
	Meigs	91	B. Kauffman
	Monroe	88	B. Kauffman
	Morgan	88	B. Kauffman
	Overton	91	B. Kauffman
	Pickett	90	B. Kauffman
	Polk	88	M. Windham, B. Kauffman
	Putnam	89	B. Kauffman
	Rhea	89	M. Windham
	Roane	88	B. Kauffman
	Scott	90	B. Kauffman
	Sequatchie	89	B. Kauffman
	Sevier	88	M. Windham, (Smokies)
	Sullivan	89	S. Dowsett
	Unicoi	89	Plot Data
	Union	90	B. Kauffman
	Van Buren	89	B. Kauffman
	Warren	90	B. Kauffman
	Washington	88	B. Kauffman
	White	90	B. Kauffman
Kentucky	Bell	90	J. Hartman
	Clark	91	J. Hartman
	Fayette	91	J. Hartman
	Hardin	91	J. Hartman
	Jefferson	91	J. Hartman
	Madison	90	J. Hartman
	Marshall	90	J. Hartman
	Powell	90	J. Hartman
	Rowan	89	S. Dowsett
	Scott	91	J. Hartman

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found--Continued

State	County	Year	Source of information
Georgia	Banks	1990	K. Baily
	Catoosa	90	M. Windham
	Cherokee	90	K. Baily
	Clarke	90	K. Baily
	Dade	90	M. Windham
	Dawson	89	F. Hendrix
	De Kalb	89	K. Baily
	Fannin	88	S. Dowsett
	Fayette	90	K. Baily
	Franklin	89	F. Hendrix
	Fulton	89	K. Baily
	Gilmer	88	S. Dowsett
	Gwinnett	90	K. Baily
	Habersham	88	Plot Data
	Hall	89	F. Hendrix
	Hart	89	F. Hendrix
	Henry	89	K. Baily
	Jackson	89	Ed Brown
	Lumpkin	89	J. Knighten
	Murray	87	S. Dowsett
	Pickens	90	K. Baily
	Rabun	88	B. Anderson, J. Knighten, S. Dowsett
	Stephens	89	F. Hendrix
	Towns	89	J. Knighten
	Union	88	K. Britton
	Walker	90	M. Windham
	White	88	K. Britton

Report # 93-1-28

Dogwood Anthracnose Impact Assessment in the Southeast - 1992

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Abstract

Two hundred and ten permanent dogwood plots have been established in dogwood-anthracnose-affected counties in Virginia, North Carolina, South Carolina, Georgia, Kentucky, Tennessee, and Alabama. These plots were selected as a random stratified sample on a 15-minute latitude and longitude grid. The area affected in the Southeast was estimated at about 1/2 million acres in 1988 and 12.8 million acres in 1992. Mortality increased from 0 to 17 percent from 1988 to 1992, and the percent of severely damaged trees increased from 4 to 19 percent.

Introduction

Dogwood anthracnose [caused by *Discula destructiva* (3)] was found on flowering dogwoods (*Cornus florida* L.) in the Northeastern United States in the late 1970's (2). All sizes and ages of dogwoods were susceptible. In 1987, the disease was found in the Cohutta Wilderness in northern Georgia. The disease causes lower limb dieback, leaf lesions, and mortality of flowering dogwoods.

Because the disease was new to the Southeast and its effects were unknown, it was decided to establish a series of permanent plots (recommended by Coleman Doggett, North Carolina Forest Service) to assess the current effects and monitor changes over time.

Since the plots occurred on all ownerships, the USDA Forest Service and the States with affected counties assisted in the establishment and monitoring of the plots. Funding was provided by the USDA Forest Service, Forest Pest Management, Washington DC.

Methods

Two hundred and ten plots were established by State and Federal cooperators, depending on the ownership. The plots were installed on a latitude and longitude grid with a 15-minute interval. These points were plotted using a geographic information system. They were then transferred to road maps to assist in field location. The following steps were used at the map coordinate:

1. Locate nearest road to coordinate. Plot should be located within a 1-mile radius of coordinate. If no dogwood within 1-mile radius, data sheet was marked "no dogwood."

2. From edge of road, determine compass heading and walk toward plot at least 2 chains (132 feet).

3. Mark plot center.

4. Locate, tag, and mark (spray paint base of tree) the 10 dogwood trees (including dead) closest to plot center regardless of size and condition. Establish plot even if less than 10 trees.

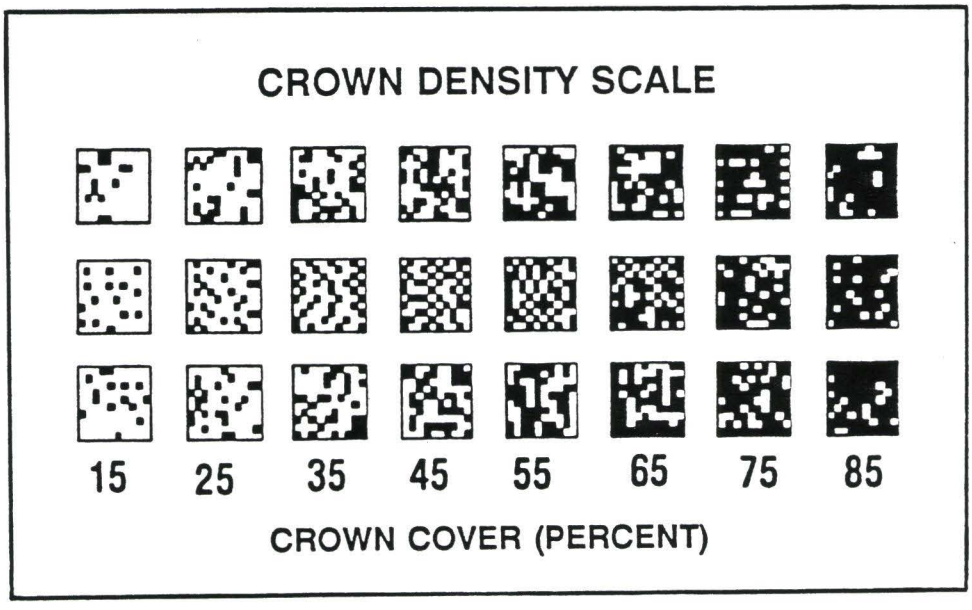
5. Make all necessary measurements and complete data sheet (fig. 1). Basal area consists of overstory trees only.

6. Collect sample of leaves or twigs from each tree suspected of having dogwood anthracnose. *Mark collection bag so it can be identified by individual tree.* Sample should be left dry and in a cool environment. Samples should be processed as soon as possible.

Data sheets were completed for each of the plots (fig. 1). The following Mielke-Langdon dieback classes (*1*) were used to rate the foliage of the trees:

Dieback classes
5 = Healthy
4 = 1-25% of foliage affected
3 = 26-50% of foliage affected
2 = 51-75% of foliage affected
1 = > 75% of foliage affected
0 = Dead

In an effort to more accurately appraise and record the condition of individual dogwoods on the impact plots, additional data were recorded on crown condition. The full crown or the upper one-third of the tree, whichever is greatest, was examined. The density of living material on this portion was visually compared and matched to a category on the density scale card (below) and resulting percentage recorded.



To allow for the wide variation of tree-crown configuration among naturally occurring dogwoods, each sample tree was examined for evidence of a pre-existing crown portion that had been lost. (If half of a crown was highly dense but the other half was dead or missing, the density estimate on the healthy portion was halved to account for the lost portion. Where there was no evidence of a missing crown segment, the crown density card was used to estimate percent crown cover, regardless of tree shape or crown configuration).

All of the data were entered into a computer for analysis. The percentage of plots with confirmed *Discula destructiva* was determined for each State. The acreage of dogwood for each county in each State was obtained from Forest Inventory and Analysis. The percentage of plots affected was then multiplied by the acres to estimate the acres affected by State (e.g., dogwood acres in county times percent of positive plots).

Thirty of the 1988 plots that have been revisited in 1989, 1990, 1991, and 1992 were used to assess the change in damage classes using the Mielke-Langdon scale.

A GIS system was used to display the approximate location of each plot for this report.

Results and Discussion

Figure 2 shows the location of the permanent dogwood anthracnose plots in the Southeast. In 1988, 14.8 percent of the permanent plots had confirmed *Discula destructiva* damage. This proportion increased to 27.8 percent in 1989, to 50.3 percent in 1990, 64.3 percent in 1991, and 79 percent in 1992. Using these percentages and estimates of total number of acres of dogwoods in infected counties (from Forest Inventory and Analysis data), the acreage affected was estimated at 1/2 million acres for 1988, 2.2 million acres for 1989, 5.7 million acres in 1990, 9.6 million acres in 1991, and 12.8 million acres in 1992 (table 1).

Since each tree is classified on the Mielke-London scale, 30 plots that were infected and have been remeasured three times were compared for changes over time. Table 2 shows that mortality has increased from 0 to 17 percent and severely damaged trees (codes 2 and 1) have increased from 4 to 19 percent. The proportion of trees assigned to the dead or severely affected classes (codes 2, 1, and 0) rose from 4 to 36 percent in a 4-year period.

In 1991, 30.7 percent of all live trees examined had a crown-cover percentage between 36 and 45 percent and 22.7 percent of the trees had a crown-cover percentage between 46 and 55 percent (table 3). Since dogwood is an understory species, these relatively low readings should be expected. The data also indicate there may be a relationship between crown-cover and dogwood anthracnose. The percentage of trees infected with *D. destructiva* increases as the percentage of crown-cover decreases for crown-cover classes below 86 percent (table 3). The number of trees with 86 percent or higher crown-cover was too small for a reliable estimate for that class (table 3).

Overall, the severity of dogwood anthracnose appears to have increased markedly in affected areas, and the disease has moved into a larger number of new sites in the Southeast. Part of the increase in affected area is a result of finding areas that have been infected for some time, and the other part is from recent spread. The disease continues to be most severe at high elevations and in cool wet areas close to streams. These data are being used to construct hazard maps, which are not ready for use at this time.

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2. **Daughtrey, M.L., C.R. Hibben, and G.W. Hudler.** 1988. Cause and Control of Dogwood Anthracnose in Northeastern United States. Journal of Arboriculture 14(2):55.

3. **Redlin, Scott, C.** 1991. *Discula Destructiva* Sp. Nov., Cause of Dogwood Anthracnose. Mycologia, 83(5), 1991, pp. 633-642.

Table 1--Percentage and total acres affected by dogwood anthracnose in the Southeastern United States, with changes from 1988-92

State	1988			1989			1990		
	Total acres	Acres affected	Acres affected	Total acres	Acres affected	Acres affected	Total acres	Acres affected	Acres affected
		Number	Percent		Number	Percent		Number	Percent
AL	0	0		0			0	0	
GA	693,132	153,875	(22.2)	1,847,076	369,415	(20.0)	2,313,671	832,922	(36.0)
KY	0	0		0	0		0	0	
NC	1,313,906	123,507	(9.4)	1,947,729	531,730	(27.3)	2,809,184	1,519,769	(54.1)
SC	899,385	158,292	(17.6)	1,005,699	295,675	(29.4)	1,005,699	737,177	(73.3)
TN	760,277	253,172	(33.3)	2,049,881	655,962	(32.0)	2,590,118	1,313,190	(50.7)
VA	90,765	13,433	(14.8)	1,246,177	346,437	(27.8)	2,619,682	1,205,054	(46.0)
Overall	3,757,465	556,105	(14.8)	8,096,562	2,250,844	(27.8)	11,338,354	5,703,192	(50.3)

Continued

Table 1--Percentage and total acres affected by dogwood anthracnose in the Southeastern United States, with changes from 1988-92--Continued

1991			1992		
Total acres	Acres affected	Acres affected	Total acres	Acres affected	Acres affected
	Number	Percent		Number	Percent
0	0		547,100	199,144	(36.4)
2,313,671	1,059,661	(45.8)	2,531,376	1,265,688	(50.0)
579,380	0		1,436,830	1,436,830	(100.0)
2,809,184	1,873,725	(66.7)	2,809,184	1,896,199	(67.5)
1,005,699	804,559	(80.0)	1,005,699	790,479	(78.6)
3,046,050	2,043,899	(67.1)	3,046,050	2,918,116	(95.8)
4,769,194	3,610,279	(75.7)	4,769,194	4,187,352	(87.8)
14,523,178	9,584,923	(66.0)	16,297,092	12,874,703	(79.0)

NOTE: Alabama acreage data were not available for this report until 1992.

Table 2--Percentage of dogwood trees in each of six damage classes, with changes from 1988 to 1992

Damage class[1/]	1988	1989	1990	1991	1992
			Percent		
5	38	8	24	24	15
4	51	66	48	38	36
3	7	17	14	15	13
2	3	4	7	7	7
1	1	4	4	7	12
0	0	1	3	8	17

1/
5 = Healthy
4 = 1-25% of foliage affected
3 = 26-50% of foliage affected
2 = 51-75% of foliage affected
1 = > 75% of foliage affected
0 = Dead

Table 3--Number and percent of all live trees and percentage of trees positive, by crown-cover groups

Crown-cover groups	Number of trees	Percent of trees	Percentage of trees positive
15% or less	176	10.3	71.0
16 - 25%	158	9.3	55.7
26 - 35%	227	13.7	50.7
36 - 45%	524	30.7	47.3
46 - 55%	387	22.7	48.1
56 - 65%	135	7.9	47.4
66 - 75%	45	2.6	28.9
76 - 85%	44	2.6	13.6
86% or more	11	0.6	45.5
Total	1,707		

Figure 1--Data sheet used to record data at each of the 210 permanent dogwood anthracnose plots - 1992.

DOGWOOD ANTHRACNOSE IMPACT SURVEY

State: _____ County: _____ Surveyor: _____

Location (Grid etc.): _____ (Draw map on back)

Aspect: _____ Elevation: _____ Basal Area: _____

Overstory Type: _____ Soil Type: _____

% Slope: _____ Landform (Ridge, Slope, Cove, Flatland): _____

Distance from plot center to farthest tree (ft): _____

Individual Tree Information

	1	2	3	4	5	6	7	8	9	10
Dieback Class										
DBH										
Height										
Stem Infection?										
Crown Cover (%)										
Sample?										
+/-										

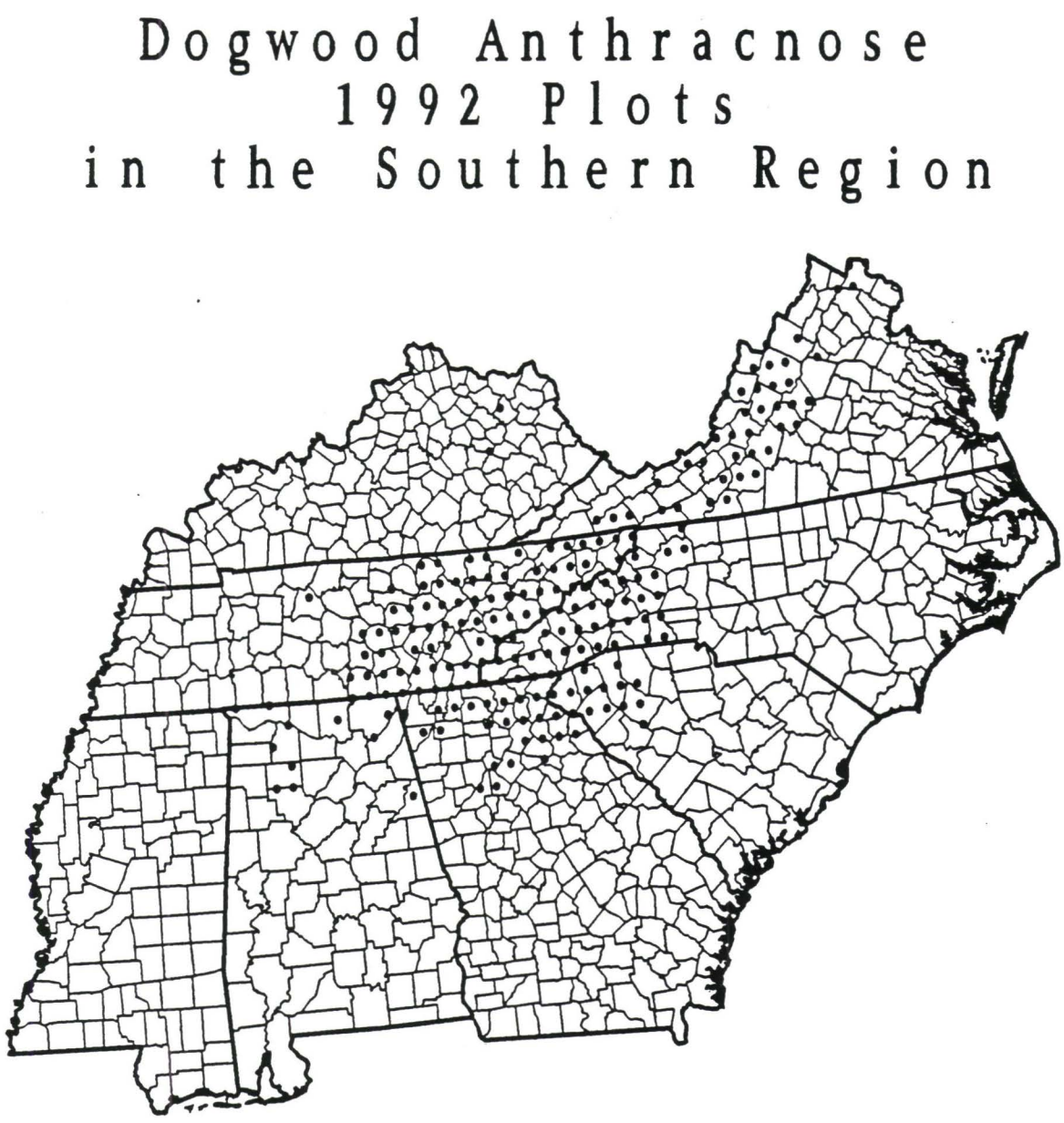
Misc. Information:

Instructions:

1. 10-tree plots on grid system.
2. Establish permanent plots - mark and number trees.
3. Record site and tree info.
4. Dieback Classes: 0 = Dead, 1 = > 75% foliage affected, 2 = 51-75%, 3 = 26-50%, 4 = 1-25%, 5 = Healthy.

Plot # # of Trees

Figure 2–Location of permanent dogwood anthracnose plots in the Southeast.



[1]Map was prepared by Bob Uhler and Steve Holzman with the Geographic Information System in the Regional Office.

A Preliminary Hazard Rating for Dogwood Anthracnose in the Southern Appalachians

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Completed through Interagency Agreement 5460-9-8016 with USDA
Forest Service, Forest Pest Management, Asheville, NC

Introduction

Background

In the mid-1970's, a new fungal disease was reported on dogwoods (*Cornus spp.*) in North America. First found near Chehalis, WA, on *Cornus nutalli*, the disease was found in successive years northward into the Puget Sound region and into British Columbia. (Daughtrey, et al. 1988). This disease caused lesions on leaves and defoliations but usually not the death of the tree. At about the same time, a new disease was found to be killing flowering dogwoods (*Cornus florida*) in the New York City area. This disease became known as dogwood anthracnose and was eventually identified as *Discula destructiva* Redlin. (Redlin, 1981). By the early 1980's, the disease was identified in Maryland and in 1987 in the southern Appalachians. A number of fundamental questions have arisen concerning dogwood anthracnose in general, such as, what is the disease's potential range? Are there climatic parameters that limit *Discula destructiva* to particular geographic areas or habitats? What are current effects of the disease on flowering dogwood, and what are likely long-term effects?

Excellent work on region-wide monitoring of the disease is being conducted by the Dogwood Anthracnose Work Group and coordinated by the USDA-Forest Service, Forest Pest Management. This project investigated the feasibility of assessing impact to flowering dogwood by *Discula* at a meso scale that is over areas of several to tens of kilometers.

This study will examine these specific, investigative questions:

1. Are there significant differences in dogwood anthracnose severity across a southern Appalachian landscape?

2. If there are differences, can these be modeled accurately enough to allow classification of sites into a hazard rating system?

3. If questions 1 and 2 above are possible, what insight into future impacts does this provide?

Methods

The methodology used focused on intensive mapping and ground truthing of both the dogwood resource and relative incidence severity of the anthracnose.

Three areas of the Great Smoky Mountains National Park, each 10 to 15 square kilometers in size, were aerially photographed during blooming season in 1989 and/or 1990 with a variety of films and at several scales.

Dogwoods in flower were mapped, and ground crews sent to rate dogwood stands continuously along transects. These transects were selected to coincide with the stands, bisect them and extend into putative non-dogwood habitats. The width of each transect varied from about 50 meters to approximately 75 meters, depending on survey party size and visibility in the stand. That portion of the stand visible was classified into one of six categories of anthracnose activity (see below) and carefully hand-drawn onto 1:24,000 topographic maps. Each category was color-coded on field maps, a total of 10 kilometers were rated:

1. Few or no dogwoods

2. Dogwoods present but little or no anthracnose apparent

3. Generally light infections (usually lower branches and seedlings) on up to 50 percent of visible trees

4. Moderate infection - more than 50 percent of trees with infection, but most not severely affected (loss of canopy, dying)

5. Severe infection - most infected and more than half with loss of canopy and usually some mortality

6. Dying - half or more dying or already dead.

This effect was expanded in later efforts to an additional 186 kilometers (115 miles) of trails mapped for dogwood infection. All trails were in natural zones; woods edge, and utility and transportation corridors were avoided.

Currently, several vegetation-related Geographic Information System (GIS) themes are available for full park coverage. They were tested for "best fit" with field results. The GIS themes below were developed or customized by Dr. Charles Parker at the Uplands Field Research Laboratory.

Theme	*Resolution*	*How Used*
Vegetation type	$90m^2$	Comparison of 13 vegetation types made dogwood and anthracnose maps
Aspect (from Digital Elev. Models)	$90m^2$	Compared northerly (WNW to ENE aspects) to southerly aspects
Proximity to streams	Line data from USGS quads	Searched out 1, 2, and 3 pixels from stream segments of various orders
Topographic sheltering	$90m^2$	Topographic exposure checked against anthracnose and dogwood distribution

Moisture	$90m^2$	Two models with 9 and 13 classifications, based on topography, were used for comparison

Various combinations of these themes were tested for "best fit" after it became obvious that single themes under or over predicted either geographic extent or severity. Since each theme may have multiple attributes (e.g., streams may be either first, second, or third order, and may be searched out one, two, three, or more pixels), large matrices quickly developed. The largest matrix had 42 values to which low, moderate, and high were assigned, as general risk categories of anthracnose.

As each major theme combination was produced graphically, another transect was selected for ground truthing. Specific routes were selected to test the accuracy of the new GIS attributes used.

Finally, to improve our assessment of impact on flowering dogwood, additional surveys were undertaken to accurately determine the distribution of host. Sixty-five sites were subjectively selected to assay relative abundance of tree species. This information was combined with existing data to construct a range map of flowering dogwood on GIS. The range of dogwood was then overlain with the map of risks to anthracnose severity.

Results

The air photos taken were very useful in delineating blooming stands, although northerly slopes bloom later, and most small trees or younger stands do not produce enough of a floral display to be detected in aerial photography. The best results were obtained with large scale, natural color photos, taken in slightly overcast conditions. Shadowing by clouds provided much greater contrast between the bright white bracts of the dogwood and the underlying forest litter.

As expected, many theme attributes and some entire themes, such as the vegetation type, were found to be of little value, either singly or in combination. Also some themes encompassed disease extent well but had little sensitivity to severity of anthracnose.

The best results were obtained using the following GIS prescription:

> Elevation and aspect - on northerly slopes, only elevations below 3,000 feet used due to scarcity of dogwood stands above that elevation. On southerly slopes, elevations below 3,500 feet were used. Dogwoods occur above that elevation, but *stands* are much more uncommon.
>
> Stream proximity - southerly slopes were considered to be at moderate risk only for the pixel through which the stream flowed. Southerly slopes farther from streams were classified as of low risk. Northerly slopes were generally considered to be of moderate risk, unless within one pixel of first-order streams or two pixels of second-order streams, which were classed as high risk.

Field Survey of Stands (196 Linear Kilometer)	Risk Prediction by Model			
	High infection	Moderate infection	Light infection	No dogwood predicted (too high)
Dead or dying (black)	59%	19%	11%	11%
Severe (red)	50%	26%	22%	2%
Moderate (orange)	40%	38%	21%	1%
Light (yellow)	35%	34%	30%	1%
Little/no anthracnose (green)	32%	36%	19%	13%
No dogwoods (blue)	18%	28%	21%	33%

The risk prediction model shows general accuracy, especially for predicting worst impact areas. More difficulty is encountered in predicting where moderate and light infections are on the landscape. This is believed to be influenced by the fact that the park's infection is still "immature," having been first detected in 1988 and increasing in intensity yearly. (Windham, et al. 1993). Note that about 28 percent of the time the model predicted that it was too high in elevations where dogwoods were found.

To grossly estimate the total anthracnose effect on the park's dogwood resource, additional surveys of host range were undertaken and mapped via GIS. Several host range characteristics became evident in this preliminary distribution mapping effort.

1. Dense stands of *Cornus florida* mostly occur below 2,600 feet elevation, on slope of 20 degrees or less, within approximately 300 meters of streams - 59,408 hectares area.

2. Less dense stands occur higher along streams to about 3,000 feet elevation on southerly slopes - 3,168 hectares area.

3. Sparse stands occur away from streams on southerly slopes, especially in mesic oak stands, up to 4,000 feet elevation - 8,493 hectares area.

The dense stands of flowering dogwood (#1, above) on low elevation alluvial corridors, probably contain the vast majority of dogwood individuals in the park. Using the above stand distribution criteria, a conservative (and preliminary) range map for *Cornus florida* was produced for the first time. This map was then overlain with the anthracnose risk model.

This analysis showed that about 58 percent of the dense dogwood stands in the park are at high-to-moderate risk of mortality due to *Discula destructiva* infections in stands. Other stands are also at significant risk, but less so. If this is true, then the majority of the park's dogwoods on high productivity sites will perhaps be permanently lost. In addition, if the model is too conservative in predicting losses to stands, then the situation is very serious, with extirpation of the host over much larger areas than the sites currently known in the park.

Relating back to the investigative questions:

1. There are significant differences in dogwood anthracnose severity across the park landscape. Some of the differences seen may be temporary as the disease progresses into more severe status.

2. A model has been produced which is generally accurate for predicting the worst impacted sites. Further assessment of dogwood hazard may have to wait until the disease stabilizes.

3. The future of flowering dogwood in the park and similar areas is serious. A large number have already perished, possibly taking much of the genetic base with them. It is possible that low risk areas may avoid significant mortality until the disease incidence is reduced through host loss in high-to-moderate risk areas. This project indicates, however, that low risk sites are low-density stands of dogwoods and probably less productive. It is also reasonable to assume that population on more xeric sites may not be genetically similar to those on colder and/or moister sites.

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Increased Dogwood Anthracnose Severity in Great Smoky Mountain National Park from 1988-1992

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Dogwood anthracnose, caused by *Discula destructiva* sp. Nov. Redlin (*3*) threatens the flowering dogwood (*1*) and has been monitored in 39 permanent plots in the Great Smoky Mountain National Park (GSMNP) for 5 years. Plots were selected at random by using a 5 km scale grid on a 1 to 125,000 scale map of the park. Plots were visited once a year from 1988 to 1992 to determine disease severity and reproduction potential of 10 tagged trees in each plot.

Disease severity was estimated using the Miekle-Langdon die-back scale (*2*), which is described in figure 2. Tree death attributed to dogwood anthracnose included trees that had been girdled by elliptical cankers and/or had severe dogwood anthracnose symptoms in previous years. Dogwood reproduction was estimated using the scale given in figure 2.

Results and Discussion

The number of plots with severe dogwood anthracnose epidemics continued to increase throughout the 5-year period (fig. 1). In 1992, severe epidemics (>25 percent of tree foliage blighted) were detected in 88 percent of the plots. This represented a 138 percent increase in the number of plots with a severe epidemic when compared to 1991 data and a 638 percent increase from 1988. During the same time period, the number of plots with healthy trees dropped from 60 percent in 1988 to 4 percent in 1992. Whether the observed change in dogwood health status was due to *D. destructiva* being recently introduced into the park or due to changes in the environment or pathogen is unknown.

Dogwood reproduction has declined in the GSMNP during the 5-year survey period and these results were similar to observed reductions observed in Catoctin Mountain Park (*2*,*4*). Decreased reproduction potential was associated with increased dogwood anthracnose disease severity (fig. 2) within the plots. In plots with severe dogwood anthracnose epidemics, dogwood seedlings were rarely found. When seedlings were found, they were severely blighted. Reduction in seedling frequency may have resulted from poor berry development in previous years due to *D. destructiva* infections of berries and seed and/or due to increased levels of *D. destructiva* inoculum from diseased foliage of mature trees within the plots.

In 1989, 2 percent of the trees in this survey had died from dogwood anthracnose. In 1992, 23 percent of trees were dead (fig. 3) while another 30 percent of trees had 100 percent blighted foliage. Tree death was not evenly scattered across all plots, but was clumped within 13 percent of plots in 1989 and 56 percent of plots in 1992. Living trees in these plots had more severe symptoms than did most trees in plots where tree mortality was not observed.

Reductions in healthy dogwood foliage and dogwood reproduction potential may result in less browse for deer in the spring and less mast for birds and mammals in the fall. High levels of dogwood mortality within some plots indicate that dogwoods will disappear from some areas of the park. Decreased reproduction potential of trees that have survived in areas of severe disease outbreaks indicate that new seedlings will not be available to replace trees as they die from the dogwood anthracnose.

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Figure 1–Percentage of plots in GSMNP in which all trees were asymptomatic for dogwood anthracnose (healthy trees), at least one tree had dogwood anthracnose lesions (disease detected), or the amount of diseased foliage within the plots was ≥ 25 percent (severe epidemics). Trees within each plot were tagged in 1988 and the same trees surveyed in 1989, 1990, 1991, and 1992.

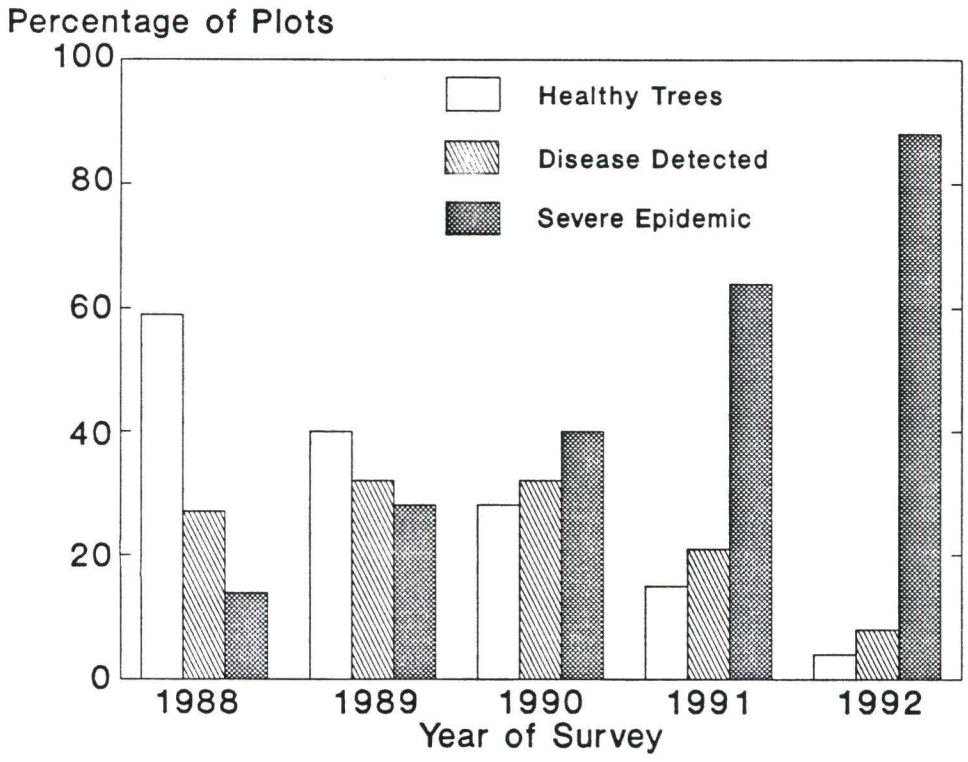


Figure 2–Percentage of plots in GSMNP in which all trees were asymptomatic for dogwood anthracnose (healthy trees), at least one tree had dogwood anthracnose lesions (disease detected), or the amount of diseased foliage within the plots was ≥ 25 percent (severe epidemics). Trees within each plot were tagged in 1988 and the same trees surveyed in 1989, 1990, 1991, and 1992.

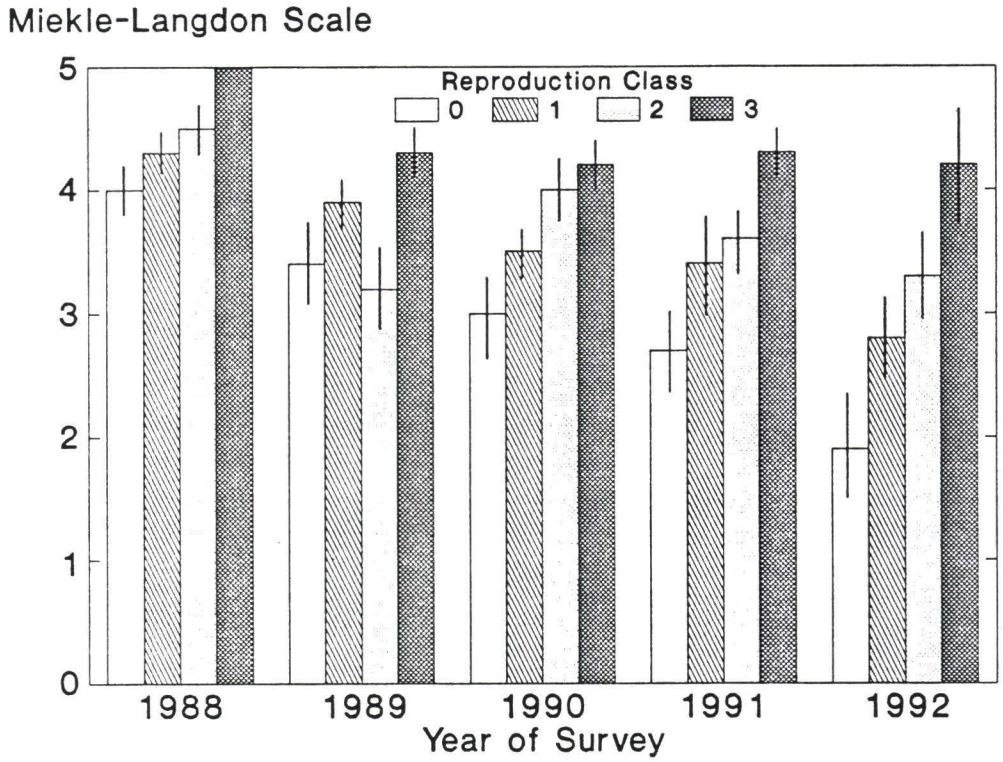
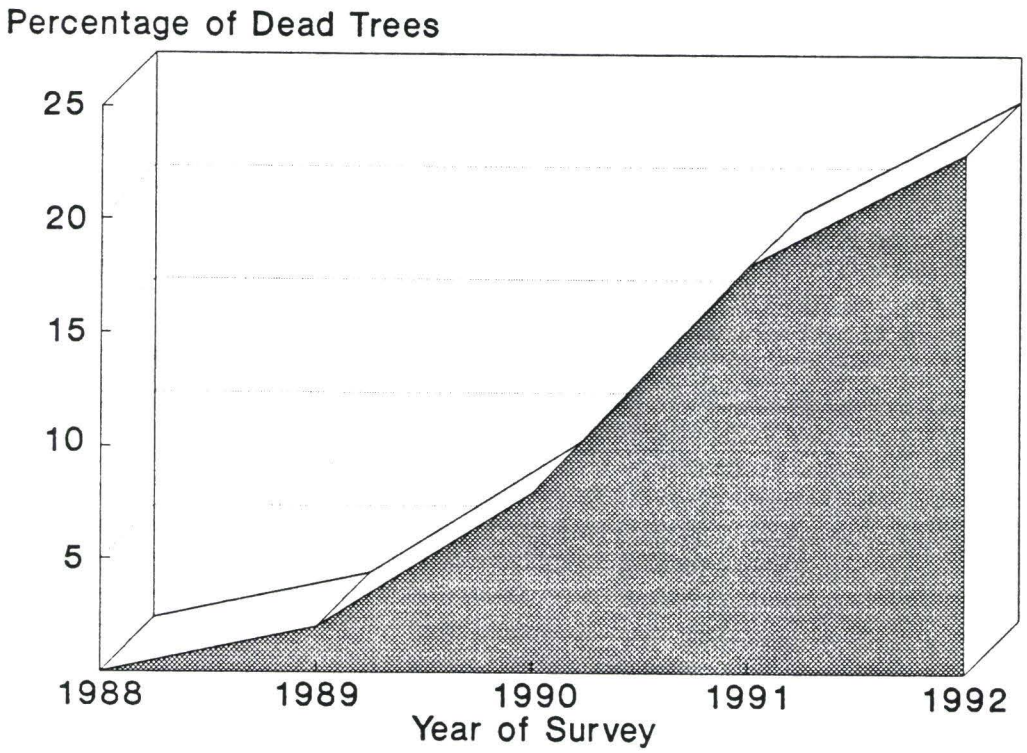


Figure 3–Percentage of trees killed by dogwood anthracnose in 1989, 1990, 1991, and 1992. Dead trees were counted only if they had severe anthracnose symptoms in the previous year and/or were girdled by elliptical cankers.



Factors Affecting Dogwood Anthracnose Severity in Great Smoky Mountain National Park

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Dogwood anthracnose incidence and severity has increased over time in Great Smoky Mountain National Park (5,6). Disease incidence and severity have increased more in some permanent plots than in others. A study was conducted to determine what environmental factors play a role in enhancing disease severity.

Material and Methods

In each of the 39 permanent plots, the following data was collected: elevation, proximity to water, and aspect (i.e. direction of the slope). Plot elevation was measured using a micro surveying altimeter (American Paulin). Proximity of plots to water was estimated using the following scale: 1= plots located 0 to 20 m from water, 2= plots located 21 to 50 m from water; 3= plots located 51 to 100 m from water, 4= plots located 100 to 200 m from water, and 5= plots located >200 m from water. Plot aspect was determined with a compass (Suunto Corp). Plot aspects were divided into the following groups: aspects of 316-45° = northern aspect; aspects of 46-135° = eastern aspect; aspects of 136-225° = southern aspect; and aspects of 226-315° = western aspect. Data presented in this report was collected in years 1988-1992. Disease severity was estimated using the Miekle-Langdon die-back scale (3).

In a separate study conducted in 1992, 16 plots were selected in the GSMNP in which four plots had either a north, east, south, or west aspect. Dogwood anthracnose severity was estimated for 10 trees using the Miekle-Langdon die-back scale. Evaporative demand (g H_20 that evaporated per day) was estimated in the plots with north and south aspects using Livingston atmometers (C&M Meteorological Supply) mounted on poles four feet above ground level.

Results and Discussion

Correlations of elevation and disease incidence and severity were not statistically significant in years 1988-1992. However, significant correlations have been found between these variables at other locations (2,4). The lowest elevation of any plot in this study was 411 m. This is considerably higher that the lowest elevation in which dogwood anthracnose epidemics were observed in the Cherokee National Forest (365 m) (4).

Trees in plots located near water were more likely to be severely impacted by dogwood anthracnose than trees located on slopes at least 200 m from water (fig. 1). High humidity is necessary for infection under artificial conditions (R. Anderson, personal communication) and may have been elevated in plots near creeks or streams than in plots on dry upland slopes. Vegetation was often more dense near streams (especially rhododendron) and may have increased humidity by reducing wind velocity and increasing transpiration rates. More research is needed to determine why trees near streams suffer more from dogwood anthracnose.

Dogwood anthracnose disease severity was higher within plots with northern aspects (316-45°) than within plots with eastern, southern, or western aspects (fig. 2). However, the percentage of healthy foliage declined regardless to plot aspect in 1989-1992 when compared to data collected in 1988. In a separate study, trees in plots with northern aspects had significantly more severe symptoms than did trees in east, south, or west aspects (fig. 3). Evaporative demand was significantly higher in the plots with southern aspects than in plots with northern aspects (fig. 4). Evaporative demand would increase with increases in amount of

sunlight, ambient temperature, wind speed, and decreases in relative humidity. Increases in evaporative demand would have a negative impact in disease development (*1*). Therefore, we conclude that the lessen disease severity observed in plots with southern aspects was due to less conducive environmental conditions encountered in those plots.

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Figure 1–Relationship between proximity of 39 plots to water and dogwood anthracnose symptom severity in GSMNP over a 5-year period. Water classes represent the distance plots are from streams, rivers, etc. and are: 1=0-20 m, 2=21-50 m, 3= 51-100 m, 4=101-200 m, and 5=>200m. Disease severity was estimated using the Miekle Langdon die-back scale (3). Vertical bar for each column represents standard error of the mean.

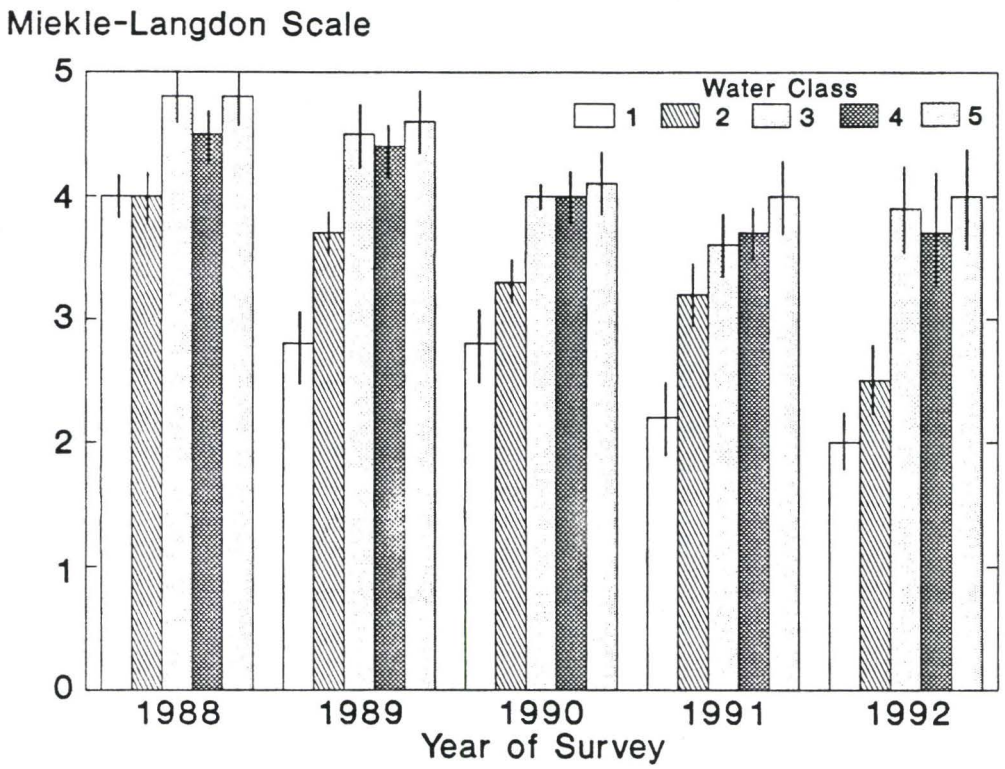


Figure 2–Relationship between plot aspect (direction plot slopes) and dogwood anthracnose symptoms severity for trees within 39 permanent plots in GSMNP over a 5-year period. Aspect classes are N (north)= 316-45°, E (east)= 46-135°, S (south)= 136-225°, and W (west)= 226-315°. Disease severity was estimated using the Mielke-Langdon die-back scale. Vertical bar for each column represents the standard error of the mean.

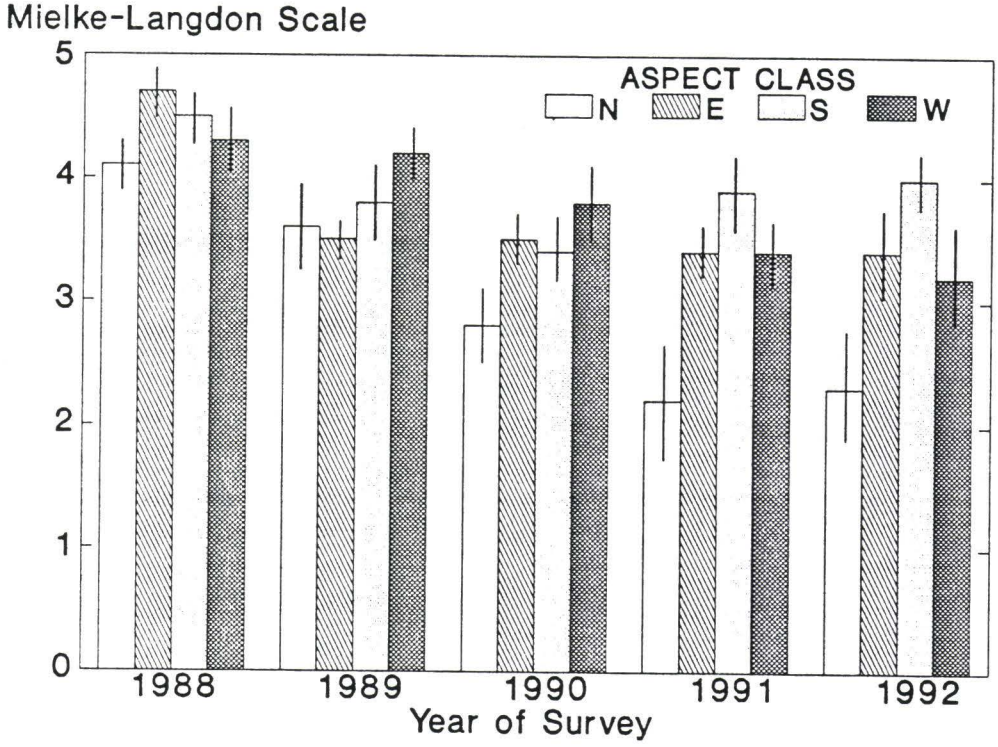


Figure 3–Affect of aspect on 16 plots (four plots for each aspect class) in GSMNP in 1992 on disease severity. Disease severity was estimated using Miekle-Langdon die-back scale (3). Vertical bars represent standard error of the mean.

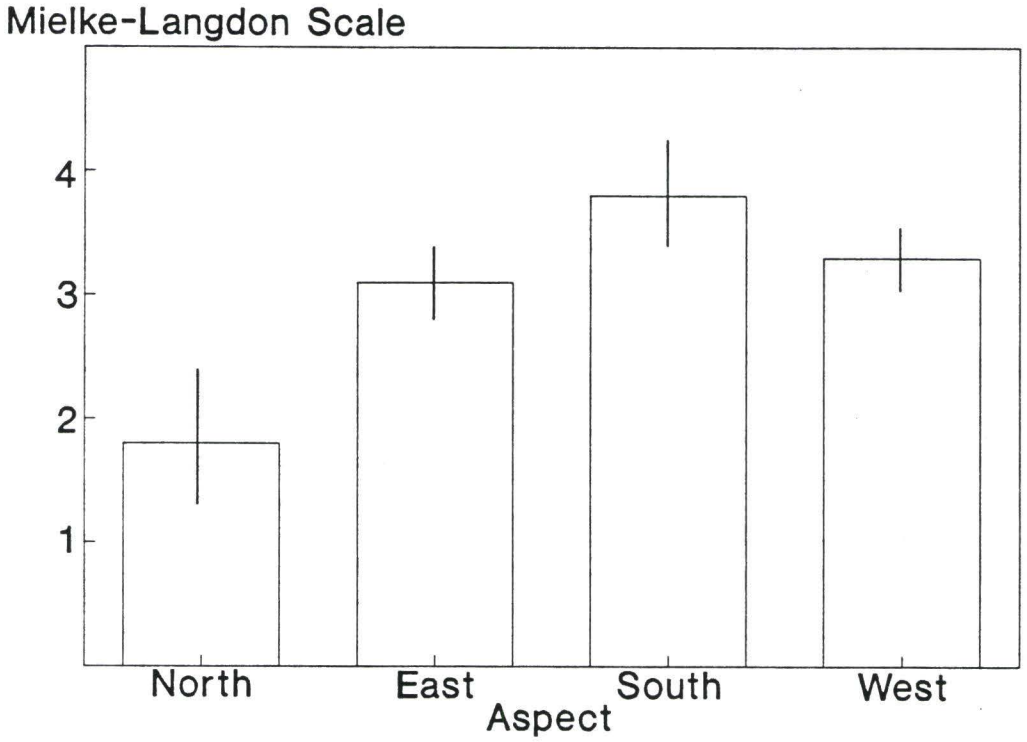
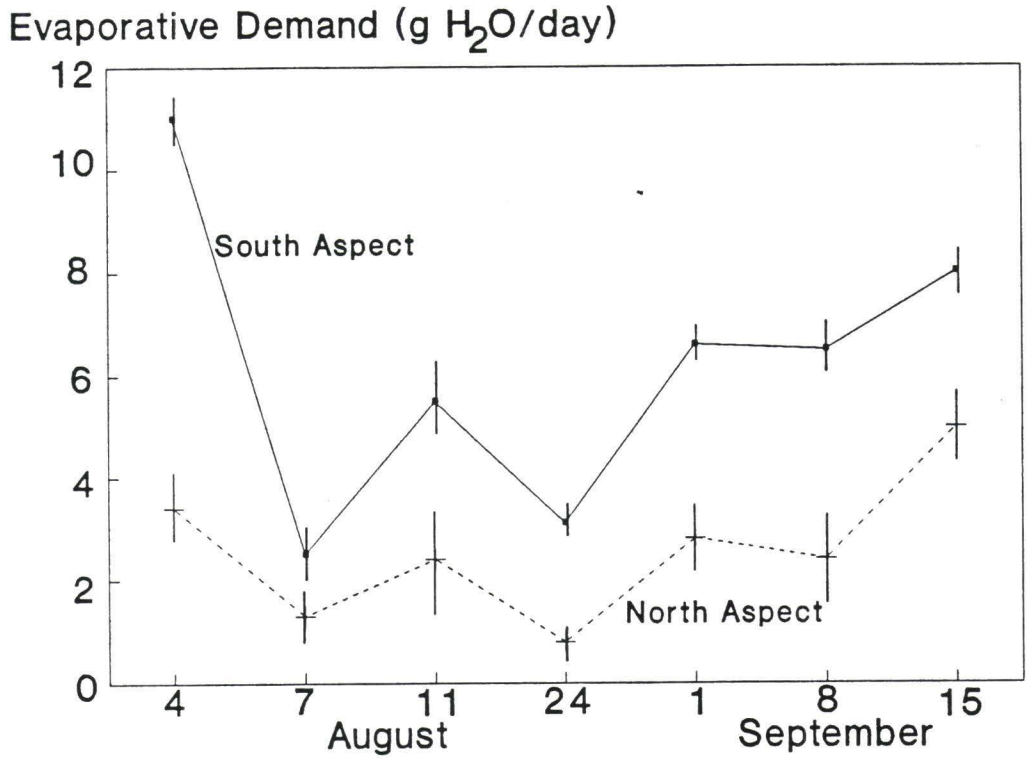


Figure 4–Evaporative demand, as measured with Livingston atmometers in four plots with southern aspects and four plots with northern aspects in GSMNP in 1992.



Report # 93-1-25

Effectiveness of Cultural Techniques, With Emphasis on Fertilization, to Control Dogwood Anthracnose

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Abstract

Ornamental dogwood trees at the Bent Creek Experimental Forest in Asheville, NC, received several cultural treatments in 1990, 1991, and 1992. All treated trees were pruned, mulched, and sprayed for dogwood borers. Some trees received nitrogen, phosphorus, lime or a balanced fertilizer, or were watered during dry periods in 1990. The check trees did not receive any of the treatments. All trees were scored for disease symptoms on a scale of increasing severity from 0 to 100. All fertilizer treatments were correlated with reduced disease symptoms in 1991 and 1992. Nitrogen and phosphorus fertilization significantly reduced disease ratings in 1991. There was however, no significant benefit from the treatments in 1992 under very severe disease pressure. The data suggest that cultural practices without fungicide treatments can reduce disease symptoms in low to moderate disease years but are not effective in severe disease years.

Introduction

Dogwood anthracnose was found in the Northeastern United States in the late 1970's. After years of experience with the disease there, pathologist have recommended a number of cultural control techniques. Since the South has a longer growing season and a variety of environmental conditions, Region 8, Forest Pest Management, began a pilot test in 1989 to evaluate recommended control techniques under southern conditions.

At the Bent Creek Experimental Forest in Asheville, NC, a number of ornamental flowering dogwoods became infected in 1989. The dogwoods were treated as recommended in the North, except no fungicides were applied. The fungicides were evaluated in another set of tests in Tennessee and Georgia. In 1990 the evaluation was continued and expanded to evaluate the effects of watering during dry periods. In 1991 and 1992 the study was continued with mulching, pruning, and dogwood borer treatments for the treated trees. Additional water was not needed in 1992.

Methods

All treated trees were pruned, mulched, and treated for dogwood borer control in 1990, 1991, and 1992. Five trees, scattered through out the area, were left untreated as checks. These trees were chosen because of their isolation from any of the treatments. The following treatments were applied in the spring of 1990:

(1) Watering during prolonged dry periods, plus 10-20-10 fertilizer (rate:1.5 lb/diameter-inch)
(2) Fertilizing with a high nitrogen (16-0-0) fertilizer (rate:3 lb/diameter-inch)
(3) Fertilizing with a high phosphorus (0-46-0) fertilizer (rate:5 lb/diameter-inch)
(4) Fertilizing with lime only (rate:200 lb/1000 sq. ft.)
(5) Fertilizing with recommended fertilizer after soil analysis (10-20-10) (rate:1.5 lb/diameter-inch)

Each treatment was replicated twice with three to six trees per replication. A buffer zone was left around each treatment to prevent different treatments from affecting each other. The fertilizer and lime were applied by broadcasting the material between the trunk and drip line. A soil analysis was made of each replication area before and at the end of the growing season in 1990.

The trees were rated for dogwood anthracnose symptoms in May, June, July, and August in 1991 and 1992 by finding the least affected and the most affected trees, which received scores of 0 to 100 percent, respectively. All other trees were visually rated on a scale from 0 to 100 percent.

In 1992 the percentage of the total crown with dieback was estimated in May. This estimate included crowning tip dieback and did not include natural branch mortality in the interior and lower crown.

Results and Discussion

In 1990 all of the treatments were associated with reduced anthracnose symptoms, but differences were not statistically significant. Nevertheless, these data suggested that any type of treatment that enhances vigor might reduce the amount of dogwood anthracnose symptoms.

In 1991, the phosphorus and nitrogen treatments significantly reduced disease symptoms (table 1). Results supported the 1990 observations and indicated that it may take a year or more for the trees to respond to the treatment.

In 1992 dogwood anthracnose effects were extremely severe, perhaps because it was a wet year. None of the treatments significantly reduced infection or dieback ratings. Apparently the amount of inoculum and the environmental conditions were sufficient to overcome any benefits provided by the treatments.
These data show that in years of low to moderate infection the cultural treatments used in this study can reduce dogwood anthracnose symptoms. However, they also show that under high disease pressure the treatments alone are not sufficient to keep the disease under control. A major factor that was not included in this study is the amount of sunlight reaching dogwood crowns. Trees in the local area with full sunlight did not sustain as much infection as trees in full or partial shade. The trees in this study were not properly located to study the effects of sun exposure.

Based on these data and observation of trees in the local area we can draw some important conclusions:

1. Trees in full sun do not appear to have significant problems with dogwood anthracnose with or without cultural treatment.
2. Cultural treatment is beneficial and can provide protection under moderate to low disease years for trees in partial shade.
3. In years when the disease pressure is high the trees in partial shade will require fungicide treatment.
4. Cultural treatments are not sufficient to retard disease development on trees in full shade and fungicides will be required to maintain these trees.

Table 1--Duncan's multiple range test results for different cultural treatments imposed on flowering dogwoods infected with Discula destrucutiva

Treatment	Percent of leaf area symptomatic Test mean and significance		
	1990 1/	1991 2/	1992
High phosphorus	15 ba	5 a	44 a
High nitrogen	10 b	5 a	31 a
Water during drought	20 ba	3/	3/
Lime	13 ba	18 ba	41 a
Balanced (NPK)	28 ba	19 ba	53 a
No treatment	35 a	29 b	39 a

1/ Differences were not significant.
2/ Differences were significant at the .05 level.
3/ Treatment was not applied because of excess rain.

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Effect of Nitrogen and Phosphorus Fertilization on Dogwood Anthracnose Infection

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A research plot was established at the Georgia Mountain Station Blairsville, GA in 1990 and maintained in subsequent years to determine the effect of nitrogen and phosphorus fertilization on incidence of dogwood anthracnose foliar infection. In 1992 we compared the low rate with the moderate or higher rate of fertilization with each nutrient alone and in combination. The recommended N application rate is 90 lb/A and the recommended P levels are: low=0-50; moderate=51-100; and high=100+ lb/A. The treatments consisted of: 1) no added N or P; 2) addition of N; 3) addition of P; 4) addition of N and P. Nitrogen was applied as ammonium nitrate (33 percent N) at a rate of 300 lb/A and phosphorus as dicalcium phosphate (18 percent P) at a rate of 110 lb/A. Both N (150 lb/A) and P were applied on April 22 and on May 20 N (150 lb/A) was again applied as a split application. The plot was a randomized complete block design. Each treatment was replicated five times with each replication in a row consisting of four trees spaced 4 ft apart with two border trees between each replication. The rows were covered with a centered shade cloth (35 percent light transmission) which was 4 ft wide and located approximately 6 ft above the soil surface. The trees were irrigated with overhead sprinklers for 2 to 4 hours twice each week in the afternoon. Artificial inoculations were made on May 13 and June 5 with a suspension of *Discula destructiva* condia at a density of 1,000,000/ml. On July 16 we assessed leaf area showing necrosis using the following scale: 0=no necrosis: 1=trace to 5 percent necrosis; 2=6 to 25 percent necrosis; 3=26 to 50 percent necrosis; 4=51 to 75 percent necrosis; 5=76 to 100 percent necrosis; and 6=leaf abscised. The lower half of the crown of the two center trees in each plot were evaluated by assessing 25 leaf pairs for each individual. Average readings were as follows: 1) no added N or P - 1.04; 2) High N - 1.16; 3) High P - 0.92; and 4) High N and P - 0.81. The means were not significantly different based on an ANOVA at p=0.05. Soil samples were taken on September 3 from each replication and pooled by treatment and processed by the University of Georgia Plant and Soil Testing Laboratory. There was no correlation between nitrogen fertilization and nitrate nitrogen in the soil. Plots not fertilized ranged from 41 to 81 lb/A nitrate nitrogen whereas those fertilized ranged from 36 to 39 lb/A nitrate nitrogen. Two P levels were evident however. Plots not fertilized with P had levels of 25 to 43 lb/A, whereas those receiving superphosphate ranged from 70 to 78 lb/A. Other nutrients such as Ca, K, and Mg were in the range favorable for dogwood growth. Soil pH varied from 5.9 to 6.7.

Effect of Nitrogen Rate and pH on the Dogwood Anthracnose Fungus Development on Flowering Dogwoods (*Cornus florida*)

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Abstract

Three hundred and thirty two year old budded flowering dogwood (*Cornus florida*) plants were potted in media containing 3 pH levels (5.5, 6.0, and 6.5) and were fertilized weekly with 3 concentrations of nitrogen (50, 100, and 200 ppm). A high phosphorous and a no fertilization treatment were also included. In 1991 the trees were located under infected dogwoods, and were artificially inoculated during the growing season. By the end of 1991 only one of the six replications was significantly infected. In that replication there was a correlation with nitrogen concentration in the foliage and percent disease severity. The plants were maintained during the winter and put back into the same six field locations in the spring of 1992. At bud break, a significant amount of dieback (averaged 40.7 percent) was evident. The disease pressure in the spring of 1992 was high and plants in all treatments were infected. An average of 91.1 percent of leaves in all treatments were infected. Averaged percent severity was 55.7 percent. These data indicate that nitrogen rate was not effective in reducing the dogwood anthracnose fungus, *Discula destructiva*, given favorable environmental conditions, and high inoculum pressure.

Effect of Application Intervals and Two Rates of Banner on Dogwood Anthracnose Severity

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The effects of fungicide intervals (2 and 4 week) using Banner 1.1 E (0.16 ml/l and 0.31 ml/l) on dogwood anthracnose severity was compared with untreated controls. Each fungicide-time of application treatment was sprayed to run-off on 10 potted dogwood trees at two locations: Roaring Fork Creek in the Great Smoky Mountain National Park (GSMNP) and Ozone, TN. At each location, plots were arranged in a randomized block design underneath the canopy of mature dogwoods naturally infected with dogwood anthracnose. A spreader-sticker (Triton B-1956) was added to each fungicide solution/suspension at a rate of one drop/3.78 l. Experiments were started at Ozone on June 9, 1992 and at the GSMNP on June 11.

Disease severity was estimated for each fungicide treatment and the control using the Miekle-Langdon die-back scale. Data were analyzed using the Proc GLM procedure of SAS. Duncan's multiple-range test was used to separate treatment means.

Results and Discussion

Fungicide treatments were equally effective in reducing dogwood anthracnose severity at both 2 and 4 week spray intervals (table 1). Phytotoxicity symptoms were not observed with any fungicide treatment.

These data suggest that Banner could be used to control dogwood anthracnose with fewer applications than are currently recommended (currently 2 week applications are recommended.) Such a reduction in pesticide usage would lower the cost of the chemical control measure and the amount of pesticide released into the environment. It is unknown if similar results would be obtained if surface protectants such as Daconil 2787 or Dithane M45 were used instead of a systemic sterol inhibitor such as Banner.

Table 1--Effectiveness of two rates of Banner 1.1 E when applied at either 2 or 4 week intervals at Ozone, TN and Roaring Fork Creek in GSMNP

Banner rate	Application interval	Disease Severity*			
		Ozone		GSMNP	
		6/25	8/19	6/26	8/20
0.16ml/l	2 wk	4.9a	4.4a	4.9a	4.2a
0.16ml/l	4 wk	4.7a	3.9a	4.6a	3.7a
0.31ml/l	2 wk	4.9a	4.4a	4.9a	4.3a
0.31ml/l	4 wk	4.9a	4.2a	5.0a	3.9a
Control	--	4.2a	2.1b	4.4a	2.8b

*Disease severity was estimated using Miekle-Langdon die-back scale where 5 = healthy, 4 = 1-25%, 3 = 26-50%, 2 = 51-75%, 1 = 76-100%, and 0 = dead tree.

ab for each column, means followed by the same letter do not differ according to Duncan's multiple-range test (p= 0.05).

Evaluation of Fungicide Foliar Sprays and Different Schedules on Control of Dogwood Anthracnose

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The study site was established in the Duke's Creek Falls Area of White County, Georgia, where the disease has been present at moderate to very high levels during the last 4 years. Foliar sprays were applied to both upper and lower leaf surfaces until runoff using a backpack sprayer. Daconil 2787 90 WDG and Domain FL (46 percent ai) were tested using various spray schedules based upon pre- or post-bud break (flowers). The Daconil 2787 program consisted of: 1) application prior to bud on March 25 and April 8 and the post-bud applications approximately every 2 weeks on April 22, May 13 and 27, and June 10; 2) post-bud application only every 2 weeks as previously stated; and 3) post-bud applications only every 3 weeks on May 13 and June 5; and 4) one post-bud only spray on April 22. The Domain FL spray scheduled consisted of: 1) pre-bud break applications on March 25 and April 8; and then post-bud break applications every 2 weeks on April 22, May 13, and 27 and June 10; 2) post-bud applications only every 2 weeks as previously stated; 3) post-bud only application every 3 weeks on May 13 and June 5; and 4) one post-bud only application on April 22. Controls consisted of water sprays applied either pre- and post-bud or post bud only. Each replication consisted of a single tree and each treatment was replicated four times with the plot being a completely randomized design.

Disease assessment was based on estimated percentage of leaf necrotic on a scale of: 0 = no symptoms, 1 = trace to 5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100%, and 6 = leaf abscised. Twenty five leaf pairs in the lower half of the crown of each tree rated on May 27 and June 16, 1992. Data were processed by analysis of variance and means were separated by Duncan's multiple-range test, P = 0.05.

Disease incidence and severity were extensive due to frequent rainfall and cooler than normal temperatures. Because of extensive defoliation due to an infection period in late May and early June, the test had to be terminated on June 16. Readings taken at that time were conservative underestimating disease severity since many leaves in 5 and 6 rating categories were abscised. Domain provided the best control of leaf infection, however, there was no correlation between control efficacy and spray frequency. Daconil did not provide effective control under there extreme conditions. We noted significant variation in infection between the two control treatments and feel that this limits interpretation of the test results.

Dogwood Anthracnose Fungicide Tests
1992

	Treatment/Rate*	Disease rating 5-27-92	Disease rating 6-16-92
	Spray treatments		
1.	Control pre-bud	1.700 A**	2.295 B
2.	Control post-bud	1.370 BC	1.595 C
3.	Daconil pre-bud + post-bud (every 2 weeks)	1.720 A	2.705 A
4.	Domain pre-bud + post-bud (every 2 weeks)	1.005 C	1.575 C
5.	Daconil post-bud (every 2 weeks)	1.285 C	2.185 B
6.	Domain post-bud (every 2 weeks)	1.345 BC	1.745 C
7.	Daconil post-bud (every 3 weeks)	1.325 BC	1.765 C
8.	Domain post-bud (every 3 weeks)	0.635 E	1.245 D
9.	Domain post-bud - 1 spray (every 2 weeks)	0.545 E	1.065 D
10.	Daconil post-bud - 1 spray (every 2 weeks)	1.420 B	1.695 C

Formulated rate

Daconil - 2787 90 WDG
Domain - FL (46 % ai)

Rate used per gallon

Daconil - 5.7 g
Domain - 5.9 ml

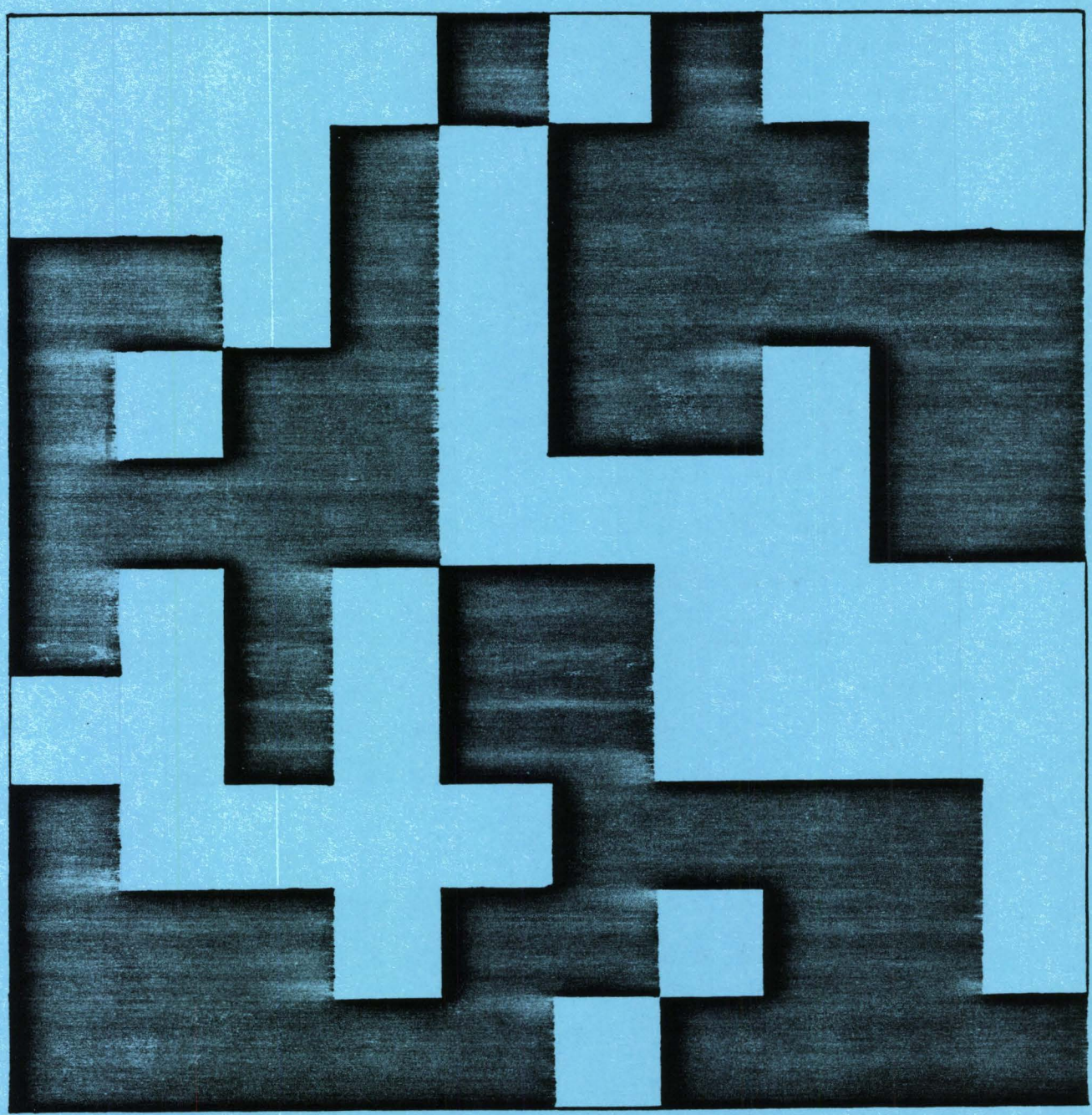
** = p = 0.05 Duncan's multiple-range test

United States
Department of
Agriculture

Forest Service
Southern Region

Results of the 1991 Dogwood Anthracnose Impact Assessment and Pilot Test in the Southeastern United States

Protection Report
R8-PR 23



Results of the 1991 Dogwood Anthracnose Impact Assessment and Pilot Test in the Southeastern United States

Protection Report R8-PR 23

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August 1992

Contents

Page

Contributors v

Background 1

Summary 5

Agencies That Participated in the Impact Assessment and Pilot Testing 6

Report Summaries 7

Individual Studies

Distribution of Dogwood Anthracnose in the Southeastern United States - December 1991 13

Dogwood Anthracnose Impact Assessment in the Southeast - 1991 21

Progress on Development of a Geographic Information System Hazard Rating for Dogwood Anthracnose 30

Distribution of Dogwood Anthracnose in the Great Smoky Mountain National Park and Effects of Proximity of Water to Plots and Plot Aspect on Disease Severity 31

Effect of Tree Placement and Plot Aspect on Dogwood Anthracnose Disease Severity and Dogwood Reproduction 36

Effectiveness of Cultural Techniques, with Emphasis on Fertilization, to Control Dogwood Anthracnose 43

Effect of Nitrogen and Phosphorus Fertilization on Infection and Disease Development 47

A Cooperative Pilot Test to Determine the Effects of Media pH, Fertilization Rates, and Moisture Stress on the Infection by the Dogwood Anthracnose Fungus (*Discula* sp.) on Flowering Dogwood, *Cornus florida* L 48

Control of Dogwood Anthracnose With Fungicide Treatments at Two Locations in Tennessee 51

Evaluation of Fungicide Foliar Sprays and Trunk Injections on Control of Dogwood Anthracnose 54

Development of an Inoculation System for Infection of Flowering Dogwoods with *Discula* sp. at the Resistance Screening Center, 1991 56

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Pesticide Precautionary Statement

This publication reports pilot testing involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife–if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Background

Dogwood anthracnose is a disease of flowering and Pacific dogwood, (*Cornus florida* L. and *C. nuttallii* Audubon). Infection of Pacific dogwood has been reported from Washington, Oregon, Idaho, and British Columbia. In the South, infections have been reported on flowering dogwood in Virginia, North and South Carolina, Tennessee, Georgia, Kentucky, and Alabama.

Infection of dogwoods is favored by cool, wet spring and fall weather but can occur throughout the growing season. Drought and winter injury weaken trees and may increase disease severity. Consecutive years of heavy infection have resulted in extensive mortality of both woodland and ornamental dogwoods. The origin of this disease is unknown, but it is suspected to have been introduced.

Dogwood anthracnose was first reported in 1978. It was causing a widespread, rapid deterioration of flowering dogwood in New York and Connecticut. In 1983, Daughtrey and Hibben (2) reported a lower branch dieback disease with the same symptoms on flowering dogwood in New York, Connecticut, New Jersey, and Pennsylvania. They made observations on trees in Planting Fields Arboretum, Oyster Bay, Long Island, and a woodland site at the Brooklyn Botanic Garden Research Center in Ossining, NY. They reported the cause of the disease to be a species of *Discula* sp. Daughtrey and Hibben (2) reported that the reason for a sudden onset of anthracnose over part of the northeastern range and its coincidental outbreak on western flowering dogwood was unknown. They speculated that climatic changes may have been a factor and that the disease may have been introduced. Hudler proposed that droughts or sudden changes in the environment may have predisposed the trees to infection (3). In 1984, a survey of dogwood anthracnose was made in Catoctin Mountain National Park. Mielke and Langdon in 1986 found that only 3 percent of the dogwoods were disease free, and that about one-third were dead (5). Schneeberger and Jackson repeated the survey in 1988 and found that 89 percent of the dogwoods were dead, that there was almost no regeneration, and that all remaining trees were diseased (7).

Byther and Davidson described a similar disease on western flowering dogwoods in western Washington and named it "dogwood anthracnose." The disease was reported in Oregon, Idaho, and British Columbia in 1983 (1). The causal organism was reported to be *Discula* sp. Daughtrey and Hibben compared the symptoms, signs, and organisms on the western flowering dogwood and the eastern flowering dogwood. They concluded that the same disease occurs in both areas. It was at this time that the disease on eastern flowering dogwood was named "dogwood anthracnose" (2). In 1985, Mielke and Daughtrey wrote a pest alert designed to help assess the distribution and spread (4). By 1987 the disease had been reported in over 60 counties in 9 Northeastern States (Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Virginia, and West Virginia). In the late 1970's and early 1980's there was considerable speculation as to whether dogwood anthracnose could successfully spread to the Southeastern United States. In October of 1987, unusual numbers of dogwoods were reported dying on the Cohutta Ranger District on the Chattachoochee National Forest in northern Georgia. All of the symptoms matched those of dogwood anthracnose. Foresters estimated that the affected area covered about 30,000 acres of the Cohutta Wilderness. *Discula* sp., the causal organism of dogwood anthracnose, was isolated from samples from the affected area.

The National Forest Supervisor and State Forester of Georgia were notified of the occurrence. Soon thereafter, Bob Zahner, a professor from Clemson University, reported an unusual problem with the dogwoods in Cashiers, NC. This area was checked and *Discula* sp. was found. In this case, the affected area was much larger than the 30,000 acres found in Georgia. The State Forester of North Carolina was notified, and a meeting of State and Federal personnel from the affected and adjacent States was held in Dillard, GA, in February 1988. This group became a dogwood anthracnose working group and agreed that the top priority was to assess the disease distribution. The Southern Region of the Forest Service distributed a southern version of the dogwood anthracnose pest alert.

By the second meeting of the working group in May of 1988, the disease had been found in Georgia, North Carolina, South Carolina, Tennessee, and Virginia. It was reported that the disease affected trees of all sizes

and was more common in the mountains and cool, wet valleys. Six nurseries in North Carolina and one in South Carolina were reported to have diseased trees. Fungicide trials were started in Georgia and Tennessee, and a joint pilot-test proposal was prepared for submission to the Washington Office. Coleman Doggett, North Carolina Pest Control Forester proposed that permanent plots be established on a 15-mile grid to assess the current and future impacts. These plots were installed by State and Federal personnel in each of the respective States. In June of 1988, the fungus had been found in so many locations that the USDA Forest Service and the University of Georgia began to provide sample identification services. In September the working group developed a news release, but it was decided not to send the release until more information was collected. After this point, the information became known to the press and public. As a result, the news release was never issued. The National Park Service did distribute a news release from the Great Smoky Mountains National Park. Dogwood anthracnose and its impact received major media coverage.

At this point, a lot of work was being done, and the working group concept was good, but the process was reactive and information was not being managed to assist in the process. The public was getting scarce information from the press, and politicians were responding to the problem without knowing the whole story. A third meeting of the dogwood anthracnose working group was held in October 1988. By this time, a funding proposal had been submitted to the Washington Office for consideration. The disease had been identified in 49 counties in the South, and 60 permanent plots had been established to assess impact. Birds were discussed as possible vectors, and fungicide studies in Georgia had not produced positive results. Fungicides had been applied in the late summer. One important concern was the inability to inoculate trees under controlled conditions. A high priority was placed on this task. In November of 1988 the Great Smoky Mountain National Park, in cooperation with the University of Tennessee, completed a survey of the Park and found the disease was widespread.

In January of 1989, the Regional Forester for the Southern Region of the USDA Forest Service called a meeting of the Federal and State cooperators to discuss dogwood anthracnose. At this meeting, a list of priorities was developed for survey, impact assessment, and research, and a dogwood anthracnose steering committee was developed to help with the biological and political aspects of the problem.

In March 1989, eight national forests were surveyed to assess the distribution. At the same time, a greenhouse inoculation test was completed with positive results. Anderson, Knighten, and Dowsett found when seedling leaves were pretreated with an acid mist, fungus spores routinely produced infections on them. Results led to a controlled acid rain study where a positive correlation was established between simulated acid rain and infection in the greenhouse. Funding was approved for a pilot test of control techniques, and several studies were started by the USDA Forest Service, the University of Tennessee, the University of Georgia, and the National Park Service.

In the spring of 1989, the media coverage picked up considerably. The story ran in dozens of newspapers and on radio and TV. CBS National News did a Saturday segment on the disease. Realizing the need to provide the best information possible to the public, the USDA Forest Service, the University of Georgia, and the State Forester of Georgia developed and published a booklet on how to manage dogwood anthracnose. To keep public officials informed, a briefing package was developed by the Forest Service. The package included a briefing paper and a list of people to be contacted. It was about this time that the correlation between simulated acid rain and dogwood anthracnose was released. Because of the interest in acid rain, major political problems arose as the information was released to the press. In 1990, the acid rain study was repeated and showed the same result. At this time, proposals for research and impact assessment were being submitted to the Washington Office. The Southeastern Forest Experiment Station assigned one person to work part time on the disease in 1989. By this time, the disease had been found in 57 counties in 7 Southern States.

By 1990 considerable information was accumulating. It was noted that the fungus seemed to remain active and grow down the dogwood shoots in the winter. The disease was more common at high elevations and in cool, wet coves was able to spread over large areas very quickly (81 counties now had diseased trees), and the

fungus preferred cool temperatures. Pilot-test data showed that the fungicides Benlate and Daconil were providing effective control and that other fungicides showed promise. Fertilization and mulching seemed to improve tree vigor, while not increasing the disease in the field. Other greenhouse and field tests were showing that phosphorus tended to increase and lime tended to reduce disease symptoms.

Nevertheless, we still knew very little about this complex problem. Early literature reported that there was no resistance in the native flowering dogwood populations, but people were noting some trees in the field that seemed to show resistance. Resistance became a high priority for research in 1990.

In September of 1989, the working group met again to discuss progress. Eighty-four counties were reported with diseased trees, and the impact plots showed the disease had increased from 1/2 million acres in 1988 to 2.2 million acres in 1989. The National Park Service announced that it would investigate mycological aspects of the problem. Forest Service research officials reported that they would be working on epidemiology.

In December 1989, Kerry Britton of the Southeastern Forest Experiment Station held a research planning meeting in Athens, GA. The Station had received funding for anthracnose research, and the purpose of the meeting was to develop a plan for the next 5 years.

Forest Pest Management recently evaluated a forest stand that had a major component of dogwood near Asheville, NC. After about 3 years of infection, 42 percent of the dogwoods have died, the remainder are infected, and there is no regeneration. The disease is spreading rapidly, heavily impacting large areas.

In the fall of 1990, the Southern Appalachian Man and Biosphere Cooperative, consisting of the U.S. Environmental Protection Agency, Forest Service, Park Service, Southeastern Forest Experiment Station, Fish and Wildlife Service, Department of Energy, Economic Development Administration, and the Tennessee Valley Authority, organized two dogwood anthracnose conferences. One was held in Knoxville, TN, and the other in Asheville, NC. These conferences consisted of representatives from Federal, State, and private concerns, and featured speakers from a number of these agencies. The program reflected a diversity of views held by various groups throughout the South. These meetings increased the awareness of and understanding of dogwood anthracnose, and helped define specific goals, such as effective information dissemination.

The distribution has been difficult to determine. For any major disease problem, the first question is "Where is the disease found?" Incidence maps are the best reply. Since there are so many mimicking symptoms, it was decided that for a county to be designated "affected," disease presence had to be confirmed in the laboratory. In 1990, the plot data were added to a Geographic Information System to generate maps displaying both severity and incidence. In 1991, the disease had been confirmed in 163 counties in 7 Southeastern States.

In January 1991, another working group meeting was held. Members reported progress in all areas. Five hundred thousand copies of an updated version of "Growing and Maintaining Healthy Dogwoods" including revised control methods were published. Also in 1991, the fungus causing dogwood anthracnose was described as "*Discula destructiva* sp. Nov." (6) and dogwood resistance screening was developed.

For impact assessment, some 210 permanent 10-tree dogwood plots have been established in North Carolina, South Carolina, Tennessee, Alabama, Virginia, Kentucky, and Georgia. These plots are selected in a random stratified sample on a 15-mile grid. Data for 1988 and 1989 show that the disease increased dramatically (from about 1/2 million acres in 1988 to 9.6 million acres in 1991), and the severity in the permanent plots has increased. Obviously, the rapid increase in the area affected and reflects discovery of stands infected for some time, in addition to actual yearly increase. However, from observation of infection in relatively large geographic areas, it is clear that there was a major increase in the disease incidence and impact in 1989, 1990, and 1991.

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Summary

By December of 1991, dogwood anthracnose had been found in 163 counties in 7 Southern States. The increase over 1990 in number of affected counties was 23 percent. About 9.6 million acres are estimated to be affected, and mortality is increasing. Preliminary work on hazard rating systems seems to show a correlation between disease severity and elevation and aspect. The higher the elevation and the more northern and western the aspect, the more severe the damage to dogwoods. In addition, work by the Great Smoky Mountain National Park has shown a relationship between disease occurrence and the proximity to water. University of Tennessee scientists have documented a major increase in disease occurrence in the Great Smoky Mountain National Park in 1991. They have also been able to demonstrate that increased sun exposure can reduce disease severity. The following recommended cultural control techniques appear to be effective in reducing disease severity:

1. Select healthy trees to plant.
2. Purchase trees from a reputable nursery; do not transplant trees from the wild.
3. Select planting sites where foliage will dry rapidly in the morning and afternoons.
4. Use proper planting techniques.
5. Prune and destroy dead wood and leaves yearly; prune trunk sprouts in the fall.
6. Water weekly in the morning during droughts. Caution: Do not wet foliage.
7. Maintain 3- to 4-inch-deep mulch around trees; do not use dogwood chips as a mulch.
8. Fertilize according to soil analysis.
9. Use proper insecticide and fungicide where appropriate.
10. Avoid mechanical and chemical injury to trees.

As a result of the pilot testing, the pruning, watering, mulching, and fungicide recommendation have been modified. General pruning seems to be of little value, but removal of epicormic shoots helps to prevent stem infection. Watering during drought is effective, but the watering must be done in the morning and must not touch the foliage. Mulching helps by reducing moisture stress and reducing trunk wounding, but too much mulch (over 4 inches) can be detrimental. All fertilizer treatments resulted in reduced infection when compared with the check.

A number of fungicides were sprayed on foliage, and injected into stems. Several fungicides worked as foliage sprays and some gave some control with injections. Two registered fungicides, Benlate and Daconil, gave excellent control as foliage sprays. Other fungicides, such as Lynx and Banner, gave better control. Lynx is not registered for this purpose but, Banner is in the process of being labeled. This is especially significant since the label for Benlate has been withdrawn.

An inoculation system was developed by the Resistance Screening Center, FPM, in 1991 to infect a large number of dogwood seedlings at one time. Also, Region 8 collected dogwood seeds from 129 geographic locations in 1991 and the Resistance Screening Center will begin screening them for resistance in 1992.

The final year of the dogwood anthracnose pilot testing will be 1992. Impact assessment will continue in 1993. The final year of pilot testing will focus on hazard rating, fungicides, fertilization interaction, and cultural control techniques. The impact assessment will continue to track the distribution and losses.

Agencies That Participated in the Impact Assessment and Pilot Testing

USDA Forest Service - Forest Pest Management

- Impact Assessment of the Southeast
- Distribution of Dogwood Anthracnose
- Cultural and Chemical Control Techniques
- Fertilization
- Resistance Screening

University of Georgia

- Chemical and Cultural Control Techniques
- Fertilization

Great Smoky Mountain National Park

- Hazard Rating
- Chemical and Cultural Control

State Foresters' Offices - Alabama, North Carolina, South Carolina, Virginia, Georgia, and Tennessee.

- Distribution of Dogwood Anthracnose
- Impact of Dogwood Anthracnose

North Carolina Department of Agriculture Extension Service

- Fertilization

Report Summaries

The individual report section contains the detailed reports for each of the assessments and pilot tests. A brief summary of each report follows:

Distribution of Dogwood Anthracnose in the Southeastern United States - December 1991 (Forest Pest Management)

Since dogwood anthracnose was found in the Southeastern United States, people from State, Federal, and private concerns have helped track its distribution. To be added to the distribution map, the diseased trees must be present in the county and have *Discula destructiva* confirmed in the laboratory. By December 1991, 163 counties in 7 Southern States were classified as having infected trees.

Dogwood Anthracnose Impact Assessment in the Southeast - 1991 (Forest Pest Management)

Two hundred and ten permanent dogwood plots have been established in dogwood-anthracnose-affected counties in Virginia, North Carolina, South Carolina, Georgia, Kentucky, Tennessee, and Alabama. These plots were selected as a random stratified sample on a 15-mile grid. The acreage affected in the Southeast was estimated at about 1/2 million acres in 1988, 2.2 million in 1989, 5.7 million in 1990, and 9.6 million acres in 1991. Mortality increased from 0 to 8 percent from 1988 to 1991, and severely damaged trees increased from 4 to 14 percent.

Progress on Development of a Geographic Information System Hazard Rating for Dogwood Anthracnose (Great Smoky Mountain National Park)

To validate the model produced in 1990, over 160 km (100 miles) of trails were rated subjectively as to the general health of dogwood stands. Criteria used to rate stands were the same as that used previously. Digitization has been completed for all data, but assessing accuracy of the dogwood anthracnose hazard rating and the new moisture model developed for the park will not be complete until mid-February 1992.

Distribution of Dogwood Anthracnose in the Great Smoky Mountain National Park and Effects of Proximity of Water to Plots and Plot Aspect on Disease Severity (University of Tennessee and Great Smoky Mountain National Park)

Dogwood anthracnose has become more severe in the Great Smoky Mountain National Park over the last 4 years and is now common on both the North Carolina and the Tennessee sides of the park. As the disease becomes more severe, tree mortality increases and dogwood reproduction decreases. If the rate of spread of the disease and the rate of mortality continue as in the last 4 years, dogwoods may completely disappear from the park (areas close to water and/or with northern aspects). Dogwoods that are growing on dry southern slopes and/or more than 50 m from water may survive for many years.

Effect of Tree Placement and Plot Aspect on Dogwood Anthracnose Disease Severity and Dogwood Reproduction (University of Tennessee)

Effects of plot aspect (direction of slope), plot elevation, and tree placement (sun or shade) on dogwood anthracnose severity and dogwood reproduction were studied at three locations: along the Blue Ridge Parkway in Virginia, in the Cherokee National Forest in Polk County in Tennessee, and on Lookout Mountain in Tennessee. Trees located in sunny areas, with south to west aspects, and/or at lower elevations (> 460 m) had less diseased foliage and higher reproduction rates than trees in full shade, with north to east aspects and/or at higher elevations (< 460 m).

Effectiveness of Cultural Techniques, With Emphasis on Fertilization, to Control Dogwood Anthracnose (Forest Pest Management)

Ornamental dogwood trees at the Bent Creek Experimental Forest in Asheville, NC, were treated with different cultural techniques. All treated trees were pruned, mulched, and sprayed for dogwood borers. In addition, some trees received nitrogen, phosphorus, lime, or a balanced fertilizer or were watered during dry periods in 1990. Check trees received none of the treatments. These trees received only pruning, mulching, and dogwood borer control in 1991. Watering was not needed in 1991. All trees were scored for disease symptoms on a score from 100 to 0, most severe to healthy, respectively. All fertilizer treatments were negatively correlated with disease development. Nitrogen and phosphorus fertilization lowered disease ratings. It appears that any fertilization, especially nitrogen and phosphorus, reduced disease severity.

Effects of Nitrogen and Phosphorus Fertilization on Infection and Disease Development (University of Georgia)

A field study of the effects of high nitrogen and phosphorus on potted dogwoods was established in 1990 and continued in 1991 at the Georgia Mountain Experiment Station in Blairsville, GA. All trees were artificially inoculated in mid-April and mid-May. Extensive development of spot anthracnose and septoria leaf spot was detected, and very little dogwood anthracnose was observed. The study will continue in 1992 with addition of shade cloth to promote anthracnose development.

A Cooperative Pilot Test to Determine the Effects of Media pH, Fertilization Rates and Moisture Stress on the Infection by the Dogwood Anthracnose Fungus (*Discula* sp.) on Flowering Dogwood, *Cornus florida* L. (North Carolina Agricultural Extension Service)

Some 330 budded dogwood plants were potted in 3 pH levels (5.5, 6.0, and 6.5) and fertilized weekly with 3 levels of nitrogen media at (50, 100, and 200 p/m N). A high phosphorus and a moisture stress treatment also were included. Plants were artificially inoculated twice with natural inoculum from the field. Only one of the six replications had significant infection. In that replication, the higher nitrogen treatment had a significantly higher infection level. All fertilized plants looked healthier than the other dogwoods in the area.

Control of Dogwood Anthracnose With Fungicide Treatments at Two Locations in Tennessee (University of Tennessee)

Twelve fungicide treatments were evaluated for dogwood anthracnose control at the Great Smoky Mountain National Park in Tennessee and at Ozone, TN. Dogwood trees sprayed with Banner or Lynx at intervals of up to 4 weeks had significantly less diseased foliage than did trees that served as controls. Trees sprayed with 0.31 or 0.63 mL/L of Banner had phytotoxicity symptoms including necrotic flecking, leaf distortion, and a silvery appearance of the leaves.

Evaluation of Fungicide Foliar Sprays and Trunk Injections on Control of Dogwood Anthracnose (University of Georgia)

Seven foliar spray and seven trunk injection treatments were imposed in the Duke's Creek Falls area of the Georgia mountains where dogwood anthracnose has been epidemic. Twenty-five leaf pairs in the lower crown of each tree were rated for percentage of leaf showing necrosis on a scale of 0 = no symptoms, 1 = trace to 5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100%, and 6 = leaf abscised. Significant disease control occurred with both foliar sprays and trunk injections. Best results were obtained with the foliar sprays Lynx, Asc 66825, and Benlate. Trunk injections with Lynx, Aliette, and Arbotect provided significant control but were relatively ineffective compared with foliar sprays.

Development of an Inoculation System for Infection of Flowering Dogwoods With *Discula* sp. at the Resistance Screening Center, 1991 (Forest Pest Management)

Several systems for screening dogwood seedlings for resistance to *Discula* sp. were evaluated at the Resistance Screening Center. The best results were obtained in an open area covered by shade cloth and misted to maintain high humidity. The inoculation procedures consisted of suspending infected branches over the seedling plus artificial inoculation.

Individual Studies

Report #92-1-25

Distribution of Dogwood Anthracnose in the Southeastern United States - December 1991

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Abstract

Since dogwood anthracnose was found in the Southeastern United States, people from State, Federal, and private concerns have helped track its distribution. To be added to the distribution map, the diseased trees must be present in the county and have *Discula destructiva* (4) confirmed in the laboratory. By December 1991, 163 counties were classified in 7 Southern States as having infected trees.

Introduction

In the late 1970's a new disease (dogwood anthracnose) was found to be causing lower limb dieback and leaf lesions on flowering dogwoods (*Cornus florida* L.) in the Northeastern United States (2). In 1987 the disease, caused by the fungus *Discula destructiva* (3,4) was found to be affecting 30,000 acres of Cohutta Wilderness in northern Georgia (1).

Since the disease's discovery in the Southeastern United States, Federal, State, and private concerns have helped track the distribution and spread of the disease. Forest Pest Management, Region 8, has coordinated the data and prepared distribution maps.

Methods

In 1987 and 1988, the States of Georgia, North Carolina, South Carolina, and Tennessee; the National Park Service; and the USDA Forest Service conducted dogwood anthracnose road surveys of the mountains and foothills in their respective areas. Symptomatic dogwoods were sampled and samples were sent to the Horticultural Research Laboratory at Cornell University for confirmation of the disease. In each State where the disease was found, counties were listed if they had at least one naturally growing dogwood tree confirmed in the laboratory to be infected with the dogwood anthracnose fungus *Discula destructiva*.

In 1989, 1990, and 1991, the survey data came from anyone that discovered an infected tree and had it confirmed in the laboratory. The person or agency reporting a specific county has been maintained from the start of the mapping activities in 1987. Counties where all of the diseased trees have been removed are not added to the map. The maps are kept up to date with a Geographic Information System by the Regional Office in Atlanta, GA.

Results and Discussion

The list of counties in the Southeast has grown from 3 in 1987 to 163 in December 1991 (fig. 1 and table 1). In 1988 and 1989, the surveys and observations were detecting new areas and places where the disease had been around for some time. The surveys and observations in 1990 and 1991 began to pick up primarily the disease spread into new areas. However, there was a concentrated effort to survey the western counties of Virginia in 1991 for the first time (table 1). The date a county was confirmed and the source of information are listed in table 2.

The disease is primarily found in the mountains, foothills, and upper Piedmont. Damage severely increases with elevation and with moistness of areas at lower elevations.

Literature Cited

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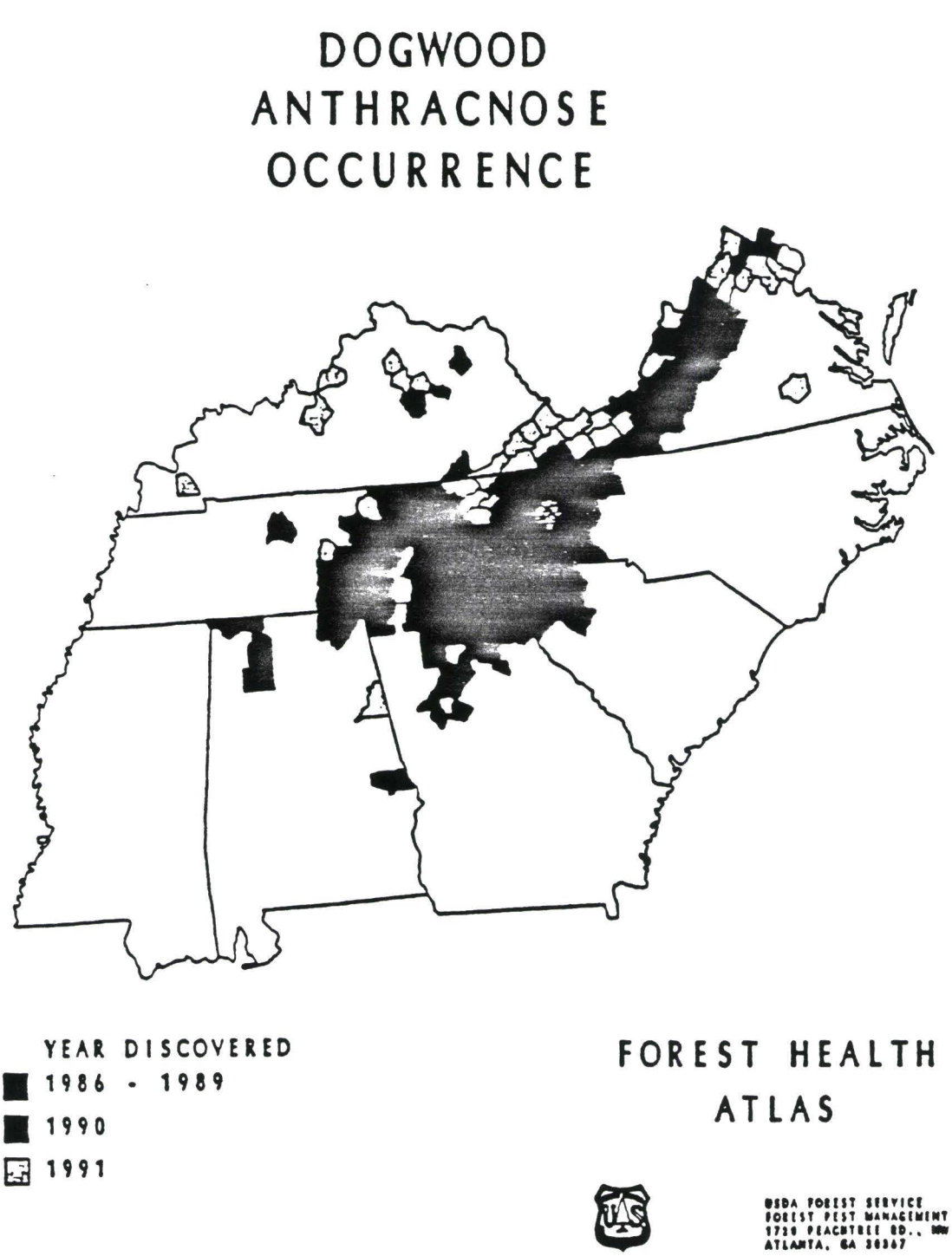
3. **Daughtery, M.L., C.R. Hibben, and G.W. Hudler.** 1988. Cause and Control of Dogwood Anthracnose in Northeastern United States. Journal of Arboriculture 14(2):55.

4. **Redlin, Scott C.** 1991. *Discula destructiva* Sp. Nov., Cause of Dogwood Anthracnose. Mycologia, 83(5), 1991, pp. 633-642.

Figure 1–Distribution of dogwood anthracnose in the Southeastern United States as of December 1991.[1]



[1]Map was prepared by Bob Uhler and Steve Holzman with the Geographic Information System in the Regional Office.

Table 1--Number of new counties in Southern States, with laboratory-confirmed dogwood anthracnose infections on at least one flowering dogwood, by year

State	Year counties were added to the map					Total
	1987	1988	1989	1990	1991	
Alabama	--	--	3	2	1	6
Georgia	1	6	11	9	--	27
Kentucky	--	--	1	4	5	10
North Carolina	--	13	5	6	--	24
South Carolina	--	5	1	--	--	6
Tennessee	--	15	14	8	8	45
Virginia	2	3	13	5	22	45
Total	3	42	48	34	36	163

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found

State	County	Year	Source of information
North Carolina	Allegheny	1989	S. Spencer, R. Baldwin
	Ashe	90	D. Rogers
	Avery	88	J. Knighten
	Buncombe	88	B. Anderson, J. Knighten
	Burke	89	S. Dowsett
	Caldwell	90	D. Rogers
	Cherokee	88	S. Dowsett
	Clay	88	S. Dowsett
	Cleveland	88	S. Oak
	Graham	88	B. Anderson, S. Dowsett
	Haywood	88	M. Windham (Smokies)
	Henderson	88	D. Ledford
	Jackson	88	B. Anderson, J. Knighten, D. Ledford
	Macon	88	B. Anderson, J. Knighten
	Madison	89	S. Dowsett
	McDowell	88	J. Knighten
	Mitchell	90	J. Knighten, S. Dowsett
	Polk	89	S. Spencer
	Rutherford	90	J. Knighten
	Swain	88	M. Windham (Smokies)
	Transylvaina	88	B. Anderson, J. Knighten, D. Ledford
	Watauga	89	NCSU Plant Path. Clinic
	Wilkes	90	D. Rogers
	Yancey	90	Plot Data
Virginia	Albemarle	90	J. Stipes
	Allegheny	91	Va. Dept. of Forestry
	Amherst	89	T. McCartney
	Augusta	89	J. Knighten
	Bath	89	T. McCartney
	Bedford	89	Blue Ridge Parkway
	Bland	91	Va. Dept. of Forestry
	Botetourt	89	Blue Ridge Parkway
	Buchanan	91	Va. Dept. of Forestry
	Carroll	89	Blue Ridge Parkway
	Clarke	87	Data from Plant Disease
	Craig	89	T. McCartney
	Dickenson	91	Va. Dept. of Forestry
	Dinwiddie	91	Va. Dept. of Forestry
	Fauquier	91	Va. Dept. of Forestry
	Floyd	88	D. Anderson
	Franklin	89	Blue Ridge Parkway
	Fredrick	91	Va. Dept. of Forestry
	Giles	89	T. McCartney

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found--Continued

State	County	Year	Source of Information
Virginia	Grayson	1989	Blue Ridge Parkway
	Greene	90	K. Langdon
	Highland	91	Va. Dept. of Forestry
	Lancaster	91	J. Artman
	Lee	91	Va. Dept. of Forestry
	Loudoun	86	Data from Plant Disease
	Montgomery	90	J. Stipes
	Nelson	88	J. Artman
	Northumberland	91	Todd Groh, J. Artman
	Page	91	Va. Dept. of Forestry
	Patrick	89	Blue Ridge Parkway
	Prince William	91	J. Artman
	Pulaski	91	J. Rauschenberger
	Rappahannock	91	Va. Dept. of Forestry
	Roanoke	89	Blue Ridge Parkway
	Rockbridge	88	Drake
	Rockingham	90	D. Rogers
	Russell	91	Va. Dept. of Forestry
	Scott	91	Va. Dept. of Forestry
	Shenandoah	91	J. Rauschenberger
	Smyth	91	Va. Dept. of Forestry
	Tazewell	91	Va. Dept. of Forestry
	Warren	90	S. Dowsett
	Washington	89	T. McCartney
	Wise	91	Va. Dept. of Forestry
	Wythe	91	Va. Dept. of Forestry
South Carolina	Anderson	89	A. Boone
	Greenville	88	A. Bonne
	Laurens	88	Plot Data
	Oconee	88	A. Boone
	Pickens	88	A. Boone
	Spartanburg	88	Plot Data
Alabama	Cleburne	91	N. Hess
	Jackson	90	B. Anderson, J. Knighten
	Lauderdale	89	N. Hess
	Lawrence	89	N. Hess
	Lee	90	W. Kelly
	Winston	89	N. Hess
Tennessee	Anderson	89	M. Windham
	Bledsoe	88	B. Kauffman
	Blount	89	M. Windham (Smokies)
	Bradley	91	B. Kauffman
	Campbell	90	B. Kauffman
	Cannon	91	B. Kauffman
	Carter	88	B. Kauffman
	Claiborne	91	B. Kauffman

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found--Continued

State	County	Year	Source of information
Tennessee	Cocke	1989	M. Windham
	Coffee	89	B. Kauffman
	Cumberland	88	B. Kauffman
	Davidson	88	B. Kauffman
	Fentress	90	B. Kauffman
	Franklin	89	B. Kauffman
	Greene	88	B. Kauffman
	Grundy	88	B. Kauffman
	Hamblen	91	B. Kauffman
	Hamilton	88	B. Kauffman
	Hancock	91	B. Kauffman
	Hawkins	90	B. Kauffman
	Jefferson	91	B. Kauffman
	Johnson	88	B. Kauffman
	Knox	89	M. Windham
	Loudon	89	B. Kauffman
	Marion	88	B. Kauffman
	McMinn	89	B. Kauffman
	Meigs	91	B. Kauffman
	Monroe	88	B. Kauffman
	Morgan	88	B. Kauffman
	Overton	91	B. Kauffman
	Pickett	90	B. Kauffman
	Polk	88	M. Windham, B. Kauffman
	Putnam	89	B. Kauffman
	Rhea	89	M. Windham
	Roane	88	B. Kauffman
	Scott	90	B. Kauffman
	Sequatchie	89	B. Kauffman
	Sevier	88	M. Windham, (Smokies)
	Sullivan	89	S. Dowsett
	Unicoi	89	Plot Data
	Union	90	B. Kauffman
	Van Buren	89	B. Kauffman
	Warren	90	B. Kauffman
	Washington	88	B. Kauffman
	White	90	B. Kauffman
Kentucky	Bell	90	J. Hartman
	Clark	91	J. Hartman
	Fayette	91	J. Hartman
	Hardin	91	J. Hartman
	Jefferson	91	J. Hartman
	Madison	90	J. Hartman
	Marshall	90	J. Hartman
	Powell	90	J. Hartman
	Rowan	89	S. Dowsett
	Scott	91	J. Hartman

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found--Continued

State	County	Year	Source of information
Georgia	Banks	1990	K. Baily
	Catoosa	90	M. Windham
	Cherokee	90	K. Baily
	Clarke	90	K. Baily
	Dade	90	M. Windham
	Dawson	89	F. Hendrix
	De Kalb	89	K. Baily
	Fannin	88	S. Dowsett
	Fayette	90	K. Baily
	Franklin	89	F. Hendrix
	Fulton	89	K. Baily
	Gilmer	88	S. Dowsett
	Gwinnett	90	K. Baily
	Habersham	88	Plot Data
	Hall	89	F. Hendrix
	Hart	89	F. Hendrix
	Henry	89	K. Baily
	Jackson	89	Ed Brown
	Lumpkin	89	J. Knighten
	Murray	87	S. Dowsett
	Pickens	90	K. Baily
	Rabun	88	B. Anderson, J. Knighten, S. Dowsett
	Stephens	89	F. Hendrix
	Towns	89	J. Knighten
	Union	88	K. Britton
	Walker	90	M. Windham
	White	88	K. Britton

Report # 92-1-23

Dogwood Anthracnose Impact Assessment in the Southeast - 1991

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Abstract

Two hundred and ten permanent dogwood plots have been established in counties affected by dogwood anthracnose in Virginia, North Carolina, South Carolina, Georgia, Kentucky, Tennessee, and Alabama. These plots were selected as a random stratified sample on a 15-mile grid. The acreage affected in the Southeast was estimated at about 1/2 million acres in 1988, 2.2 million in 1989, 5.7 million in 1990, and 9.6 million acres in 1991. Mortality increased from 0 to 8 percent from 1988 to 1991, and the percentage of severely damaged trees increased from 4 to 14 percent.

Introduction

Dogwood anthracnose [caused by *Discula destructiva* (3)] was found on flowering dogwoods (*Cornus florida* L.) in the Northeastern United States in the late 1970's (2). All sizes and ages of dogwoods were susceptible. In 1987, the disease was found in the Cohutta Wilderness in northern Georgia. The disease causes lower limb dieback and leaf lesions on flowering dogwoods.

Because the disease was new to the Southeast, and the effects were unknown, it was decided to establish a series of permanent plots (recommended by Coleman Doggett, North Carolina Forest Service) to assess the current effects and monitor changes over time.

Since the plots occurred on all ownerships, the USDA Forest Service and the States with affected counties assisted in the establishment and monitoring of the plots. Funding was provided by the Forest Service, Forest Pest Management, Washington, DC.

Methods

Two hundred and ten plots were established by State and Federal cooperators, depending on the ownership. The plots were installed on a latitude and longitude grid with a 15-minute interval. These points were plotted using a geographic information system. They were then transferred to road maps to assist in field location. The following steps were used at the map coordinate:

1. Locate nearest road to coordinate. Plot should be located within a 1-mile radius of coordinate. If no dogwood is found within a 1-mile radius, data sheet is marked "no dogwood."

2. From edge of road, determine compass heading and walk toward plot at least 2 chains (132 feet).

3. Mark plot center.

4. Locate, tag, and mark (spray paint base of tree) the 10 dogwood trees (including dead) closest to plot center regardless of size and condition. Establish plot even if less than 10 trees.

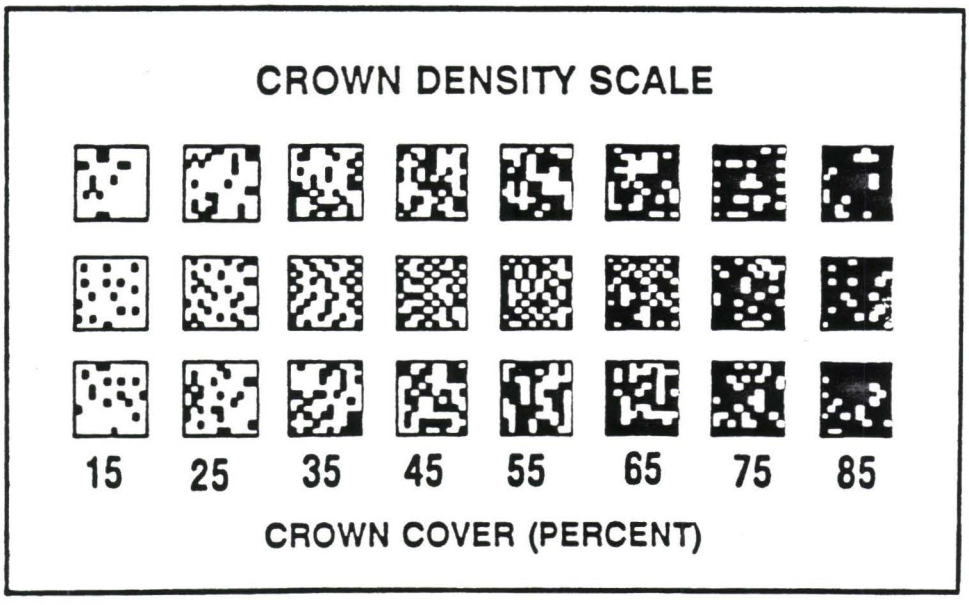
5. Make all necessary measurements and complete data sheet (fig. 1). Basal area consists of overstory trees only.

6. Collect sample of leaves or twigs from each tree suspected of having dogwood anthracnose. Mark collection bag so it can be identified by individual tree. Sample should be left dry and in a cool environment. Samples should be processed as soon as possible.

Data sheets were completed for each of the plots (fig. 1). The following Mielke-Langdon dieback classes (1) were used to rate the foliage of the trees:

Dieback classes
5 = Healthy
4 = 1-25% of foliage affected
3 = 26-50% of foliage affected
2 = 51-75% of foliage affected
1 = > 75% of foliage affected
0 = Dead

In an effort to more accurately appraise and record the condition of individual dogwoods on the impact plots, additional data were recorded on crown conditions. The full crown or the upper one-third of the tree, whichever is greatest, was examined. The density of living material on this portion was visually compared and matched to a category on the density scale card (below), and the resulting percentage was recorded.



All of the data were entered into a computer for analysis. The percentage of plots with confirmed *Discula destructiva* was determined for each State. The acreage of dogwood for each county in each State was obtained from Forest Inventory and Analysis. These county data were used to determine the total acres in affected counties, by State. The percentage of plots affected was then multiplied by the acres to estimate the acres affected, by State (e.g., dogwood acres in county times percent of positive plots).

Thirty of the 1988 plots which have been revisted in 1989, 1990, and 1991 were used to assess the change in damage classes using the Mielke-Langdon scale.

A GIS system was used to display the approximate location of each plot for this report.

Results and Discussion

Figure 2 shows the location of the permanent dogwood anthracnose plots in the Southeast. In 1988, about 14.8 percent of the permanent plots were confirmed as positive for *Discula destructiva*. By 1989 this had increased to 27.8 percent, to 50.3 percent in 1990, and to 64.3 percent in 1991. Using these percentages and estimates of total dogwood, the acreage affected was estimated at 1/2 million acres for 1988, 2.2 million acres for 1989, 5.7 million acres in 1990, and 9.6 million acres in 1991 (table 1).

Since each tree is classified on the Mielke-Langdon scale, 30 plots that were infected and have been remeasured three times were compared for changes over time. Table 2 shows that mortality has increased from 0 to 8 percent and severe damage (codes 2 and 1) from 4 to 14 percent.

The additional density (crown-cover) data is an estimate of the overall tree condition. These data show 55 percent of all live trees examined had a percentage between 26-50 percent with 34 percent of those trees positive for *D. destructiva* (table 3). Since the dogwood is an understory species, these results should be expected. The data indicate there may be a relationship between density and dogwood anthracnose. The percentage of positive trees progressively increases as the percentage of density decreases (table 3). Table 4 shows the positive plots, that 66 percent of the plot density averages were also in the 26-50 percent density group.

Overall, both the area affected by dogwood anthracnose and the severity of the disease have increased markedly in the Southeast. Some of the reported increase in area reflects newly discovered infection that have existed for some time, so only part represents truly new infections. The disease continues to be more severe at the higher elevations and in cool wet areas close to streams. These data are being used to construct hazard maps, which are not ready for use at this time.

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Figure 1-Data sheet used to record data at each of the 210 permanent dogwood anthracnose plots - 1991.

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DOGWOOD ANTHRACNOSE IMPACT SURVEY

Date_____

State: _____ County: _____ Surveyor: _____

Location (Grid etc.): _____ (Draw map on back)

Aspect: _____ Elevation: _____ Basal Area: _____

Overstory Type: _____ Soil Type: _____

% Slope: _____ Landform (Ridge, Slope, Cove, Flatland): _____

Distance from plot center to farthest tree (ft): _____

Individual Tree Information

	1	2	3	4	5	6	7	8	9	10
Dieback Class										
DBH										
Height										
Stem Infection?										
Crown Cover (%)										
Sample?										
+/-										

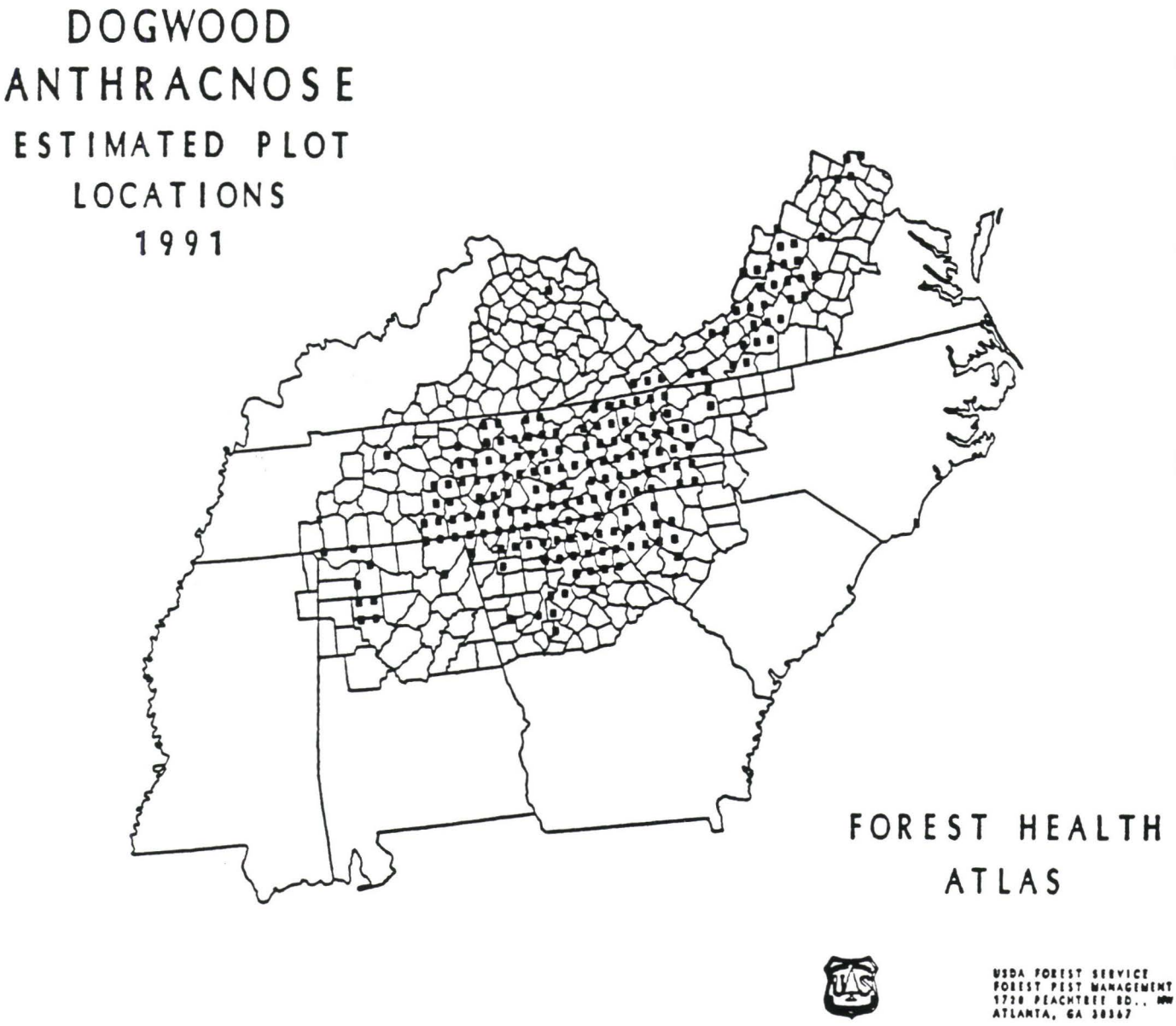
Misc. Information:

Instructions:

1. 10-tree plots on grid system.
2. Establish permanent plots - mark and number trees.
3. Record site and tree info.
4. Dieback Classes: 0 = Dead, 1 = > 75% foliage affected, 2 = 51-75%, 3 = 26-50%, 4 = 1-25%, 5 = Healthy.

Plot # # of Trees

Figure 2–Location of permanent dogwood anthracnose plots in the Southeast.[1]



[1]Map was prepared by Bob Uhler and Steve Holzman with the Geographic Information System in the Regional Office.

Table 1--Percentage and total acres affected by dogwood anthracnose in the Southeastern United States

State	1988 Total acres	1988 Acres affected Number	1988 Acres affected Percent	1989 Total acres	1989 Acres affected Number	1989 Acres affected Percent	1990 Total acres	1990 Acres affected Number	1990 Acres affected Percent	1991 Total acres	1991 Acres affected Number	1991 Acres affected Percent
AL	0	0		0	0		0	0		0	0	
GA	693,132	153,875	(22.2)	1,847,076	369,415	(20.0)	2,313,671	832,922	(36.0)	2,313,671	1,059,661	(45.8)
KY	0	0		0	0		0	0		579,380	0	
NC	1,313,906	123,507	(9.4)	1,947,729	531,730	(27.3)	2,809,184	1,519,769	(54.1)	2,809,184	1,873,725	(66.7)
SC	899,385	158,292	(17.6)	1,005,699	295,675	(29.4)	1,005,699	737,177	(73.3)	1,005,699	804,559	(80.0)
TN	760,277	253,172	(33.3)	2,049,881	655,962	(32.0)	2,590,118	1,313,190	(50.7)	3,046,050	2,043,899	(67.1)
VA	90,765	13,433	(14.8)	1,246,177	346,437	(27.8)	2,619,682	1,205,054	(46.0)	4,769,194	3,610,279	(75.7)
Overall	3,757,465	556,105	(14.8)	8,096,562	2,250,844	(27.8)	11,338,354	5,703,192	(50.3)	14,523,178	9,584,923	(66.0)

NOTE: Alabama acreage data were not available for this report.

Table 2--Percentage of dogwood trees in each of six damage classes, with changes from 1988 to 1991

Damage class[1/]	1988	1989	1990	1991
		Percent		
5	38	8	24	24
4	51	66	48	38
3	7	17	14	15
2	3	4	7	7
1	1	4	4	7
0	0	1	3	8

1/ 5 = Healthy
4 = 1-25% of foliage affected
3 = 26-50% of foliage affected
2 = 51-75% of foliage affected
1 = > 75% of foliage affected
0 = Dead

Table 3--Number of all live trees and percentage of trees positive, by density groups

Density groups	Number of trees	Percentage of trees positive
25% or less	369	51
26-50%	973	34
51-75%	302	24
76% or more	113	6
Total	1,757	

Table 4--Number of positive plots by density groups

Density groups	Number of positive plots
25% or less	31
26-50%	84
51-75%	11
76% or more	0
Total	126

Progress on Development of a Geographic Information System Hazard Rating for Dogwood Anthracnose

K. Langdon, K. Johnson, M. Windham, and S. Powell

To validate model produced in 1990, over 160 km (100 miles) of trails were rated subjectively as to the general health of dogwood stands. Criteria used to rate stands were the same as that used previously (1).

Digitization has been completed for all data, but assessing accuracy of the dogwood anthracnose hazard rating and the new moisture model developed for the park (2) will not be complete until mid-February 1992.

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1. **Langdon, K., C. Parker, M. Windham, S. Powell, K. Johnson.** 1991. "A Preliminary Hazard Rating for Dogwood Anthracnose in the Southern Appalachians" in Results of the 1990 Dogwood Anthracnose Impact Assessment and Pilot Test in the Southeastern United States. USDA Forest Service, Forest Pest Management Protection Report R8-PR20. pp. 34-38.

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Distribution of Dogwood Anthracnose in the Great Smoky Mountain National Park and Effects of Proximity of Water to Plots and Plot Aspect on Disease Severity

M.T. Windham, M.E. Montgomery, and K. Langdon

University of Tennessee Institute of Agriculture, Knoxville, TN, and Great Smoky Mountain National Park, Gatlinburg, TN

Dogwood anthracnose, caused by *Discula destructiva* Nov. Redlin (2), has been monitored on permanent plots in the Great Smoky Mountain National Park (GSMNP) for 4 years (5). Thirty-four plots were visited in 1991 and data were collected on disease severity, tree death, plot aspect and evaluation, tree d.b.h. (diameter at breast height), dogwood reproduction, and proximity of plots to water.

Disease severity was estimated using the Mielke-Langdon dieback scale (1), which is described in figure 5. Tree death attributed to dogwood anthracnose included trees that had been girdled by elliptical cankers and/or had severe dogwood anthracnose symptoms in previous years. Plot aspect was determined and plots with aspect values of 316-45°, 46-135°, 136-225°, and 226-315° were grouped together, and means and values for standard error of the means were calculated. Plot elevation was measured with an altimeter. Tree-diameter data were collected at 1.2 m from the base of the tree trunk. Dogwood reproduction was estimated using the scale given in figure 4. Distances between plots and water (creeks, rivers, lakes, etc.) were measured, and data were grouped into water classes described in figure 5.

Results

Severe outbreaks of dogwood anthracnose ($\geq$ 25% diseased foliage) were scattered throughout GSMNP (fig. 1). Trees whose death was attributed to dogwood anthracnose were found in 41 percent of the plots, and these plots were also scattered throughout the park (fig. 2). Fewer plots with all healthy trees were found in 1991 than in 1988-1990 (fig. 3), and the number of plots with severe epidemics had greatly increased. Dogwood reproduction decreased within plots as disease severity increased (fig. 4). Dogwood anthracnose symptom severity was not correlated with d.b.h. or plot elevation.

Plots located close to water contained more trees with severe anthracnose symptoms than did plots on dry slopes (fig. 5). In addition, trees within plots with a northern aspect were more severely impacted by dogwood anthracnose than trees within plots with a eastern, southern, or western aspect (fig. 6).

Discussion

Dogwood anthracnose has become more severe in GSMNP over a 4-year period. The disease is common on both the Tennessee and North Carolina sides of the park (fig. 1). As the disease has become more severe, tree mortality has increased and dogwood reproduction has decreased. Similar increases in dogwood death and decreases in dogwood reproduction have been previously noted in Catoctin Mountain Park as dogwood anthracnose became more severe (1,3).

If both the rate of spread of dogwood anthracnose and the rate of dogwood mortality continue to increase as they have during the last 4 years, dogwoods may completely disappear from some areas of the park (areas close to streams and/or with northern aspects). However, dogwoods that are growing on dry southern slopes and/or more than 50 m from water may survive for many years. Plots located near water usually had more dense understories and overstories. High density may have led to increased humidity and less light intensity near dogwood canopies. Increased humidity would lengthen the period of time that leaves stay wet after

rainy periods and thus increase the period of time for fungal sporulation. Plots with northern aspects would receive less sunlight than plots on eastern, southern, or western aspects. Parham (unpublished) demonstrated that decreased light intensities at the surface of dogwood leaves led to decreased maximum temperatures of dogwood leaves, increased rates of growth of necrotic dogwood anthracnose lesions, and increased *Discula* spp. acervuli and cirri production. These differences may explain why dogwood anthracnose severity was greater in areas near streams and/or northern slopes.

Although small dogwoods were often observed to be more severely impacted by dogwood anthracnose than larger trees, dogwood d.b.h. was not significantly correlated with dogwood anthracnose incidence or severity. Since smaller (< 1.2 m tall) dogwoods in each plot were not utilized in this study, data collection was skewed to larger trees within each plot.

Plot elevation has been found to be correlated with dogwood anthracnose incidence and severity at other locations in Tennessee (4). In a previous study where dogwood anthracnose incidence and severity increased as plot elevation increased, severe outbreaks of the disease were found as low as 365 m (4). Generally, the elevation of GSMNP is higher than most other areas in Tennessee. Elevation of the lowest plot in GSMNP was 411 m. Therefore, plots may have been located too high to observe elevation effects on disease incidence and severity.

Literature Cited

1. Mielke, M. and Langdon, K. 1986. Dogwood anthracnose fungus threatens Catoctin Mt. Park. Park Sci. Winter:6-8.

2. Redlin, S.C. 1991. *Discula destructiva* sp. Nov., cause of dogwood anthracnose. Mycologia 83:633-642.

3. Schneeberger, N. and Jackson, W. 1989. Impact of dogwood anthracnose on flowering dogwood at Catoctin Mountain Park. Plant Dis. Quarterly. 10:30-43.

4. Windham, M. 1989. Epidemiology of dogwood anthracnose in Cherokee National Forest of southeastern Tennessee. Phytopathology 79:1149.

5. Windham, M., Montgomery, M., and Langdon, K. 1989. Disease incidence and severity of dogwood anthracnose in the Great Smoky Mountain National Park. Phytopathology. 79:377.

Figure 1–Distribution of dogwood anthracnose in the Great Smoky Mountain National Park in 1991. Open circles represent plots in which all trees were healthy; half-shaded circles represent plots where < 25 percent of foliage was symptomatic for dogwood anthracnose; shaded circles represent plots where ≥ 25 percent of foliage was symptomatic for dogwood anthracnose.

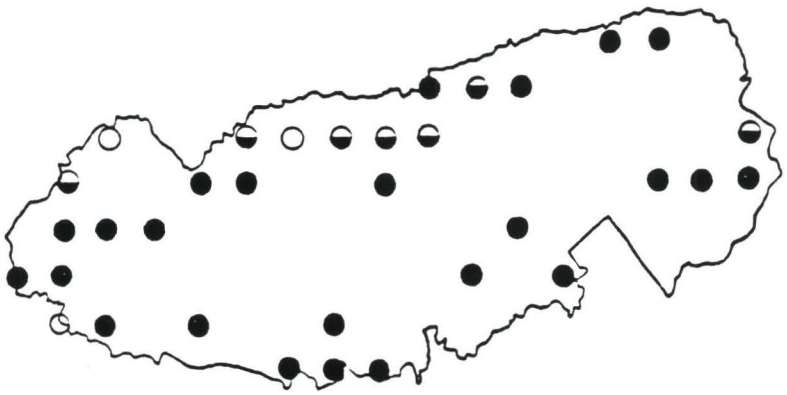


Figure 2–Distribution of plots in the Great Smoky Mountain National Park in which mortality of trees was attributed to dogwood anthracnose.

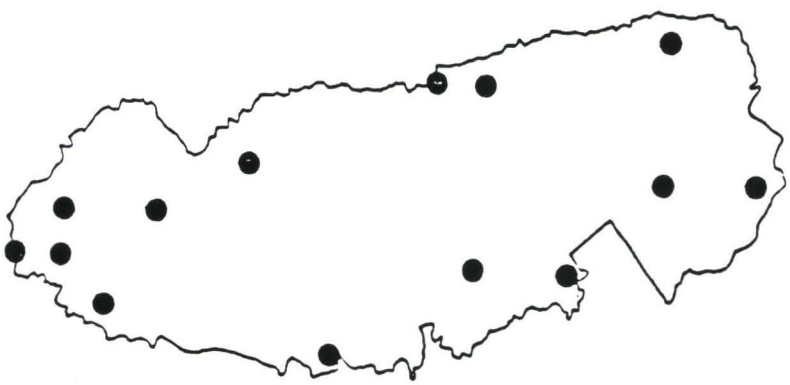


Figure 3–Percentage of plots in the Great Smoky Mountain National Park in which all trees are asymptomatic for dogwood anthracnose, atleast one tree within the plot had anthracnose lesions on its foliage, or diseased foliage within the plot ≥ 25 percent. Trees within each plot were tagged in 1988 and the same trees were surveyed in 1989, 1990, and 1991.

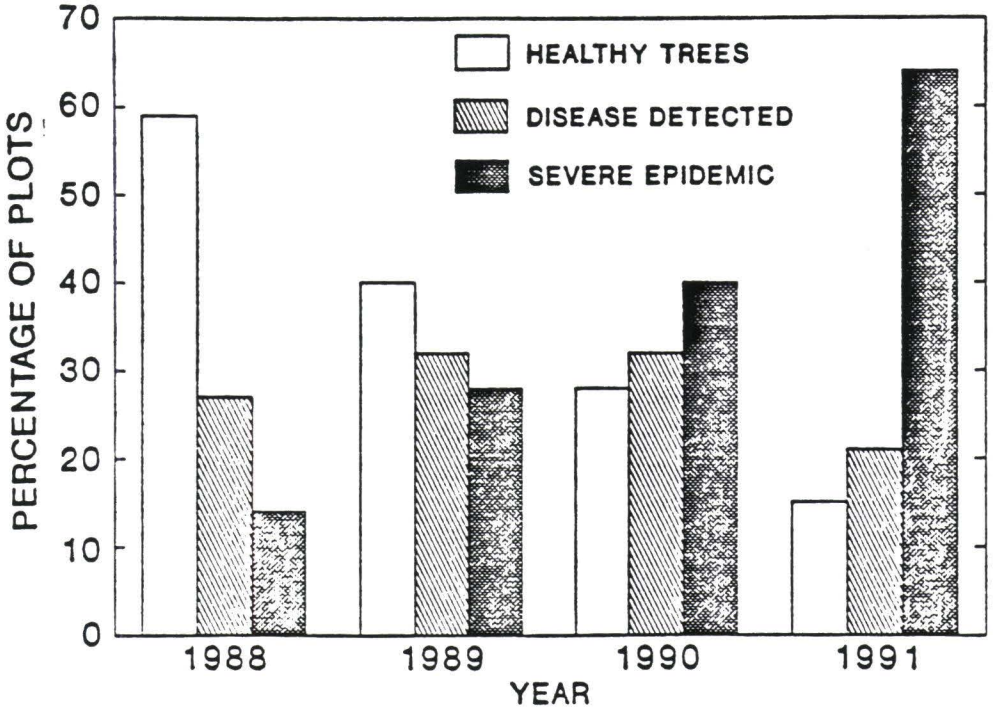


Figure 4–Effect of dogwood anthracnose disease severity on dogwood reproduction. Reproduction scale is: 0 = no reproduction, 1 = few flower buds or berries on trees; 2 = flower buds or berries common or few dogwood seedlings present; 3 = flower buds or developing berries common on trees and dogwood seedlings present.

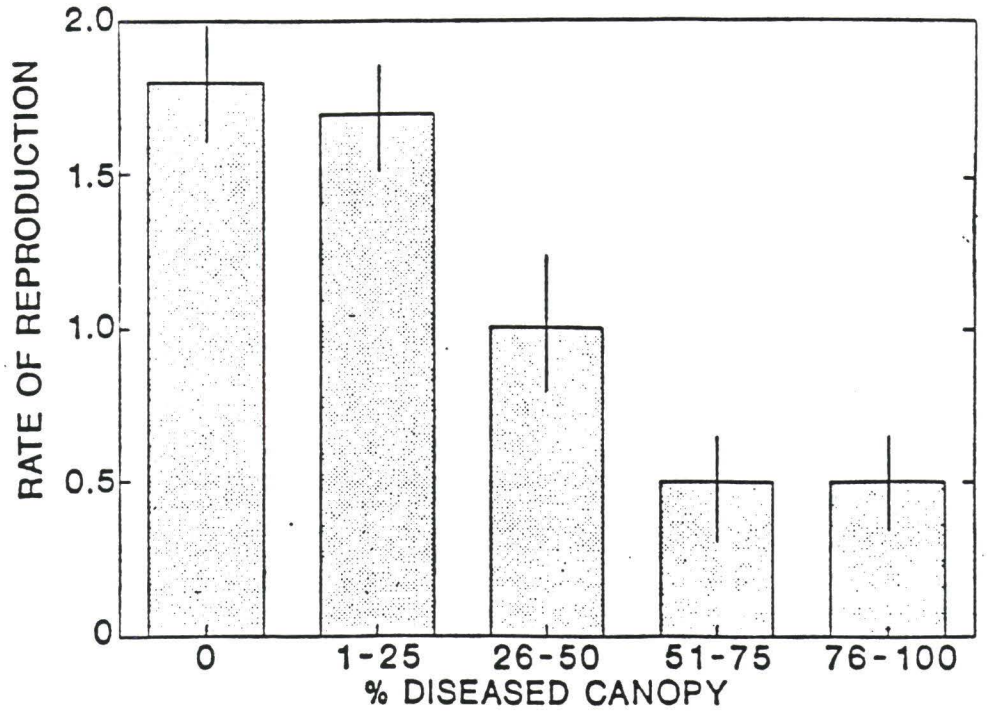


Figure 5–Relationship between the proximity of plots to water (streams, rivers, etc.) and dogwood anthracnose severity. Mielke-Langdon dieback scale (1) is 5 = healthy tree, 4 = 1-25% diseased foliage, 3 = 21-50% diseased foliage, 2 = 51-75% diseased foliage, 1 = 76-100% diseased foliage, 0 = no living foliage.

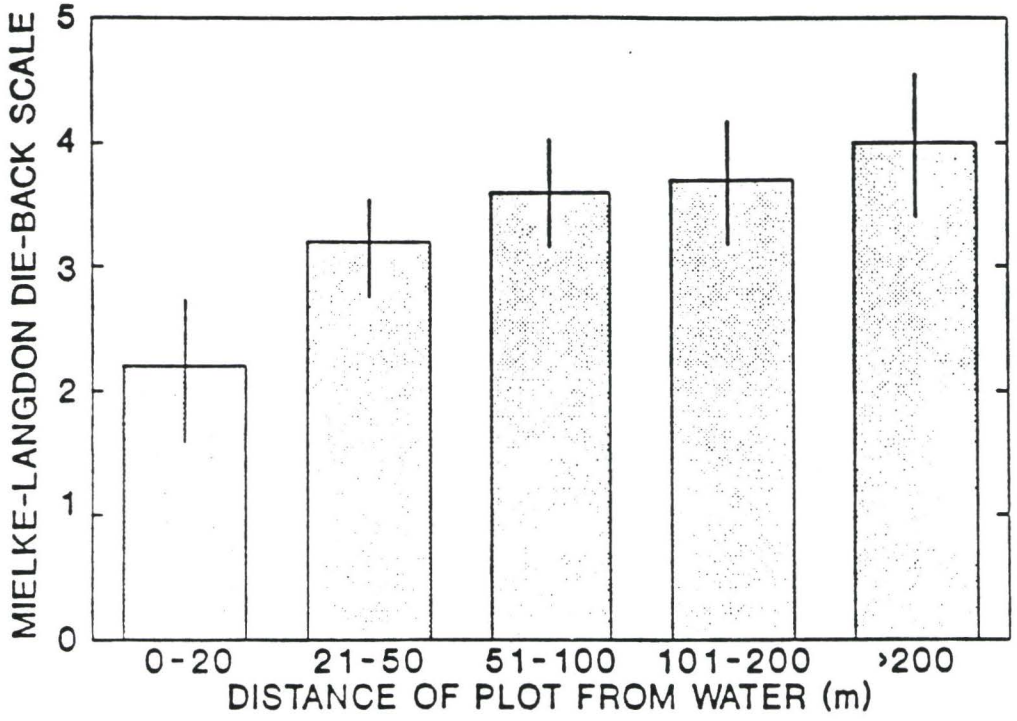
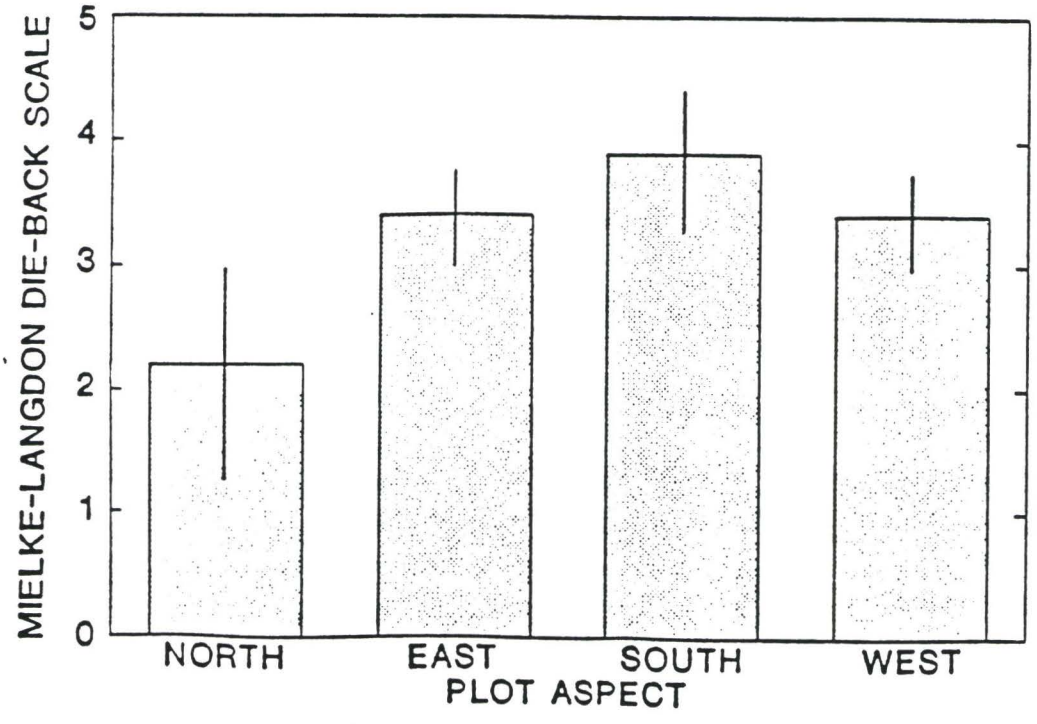


Figure 6–Relationship between plot aspect (direction plot slopes) and dogwood anthracnose symptom severity. Aspect classes are N (north) = 316-45°, E (east) = 46-135°, S (south) = 136-225°, and W (west) = 226-315°. Mielke-Langdon scale is explained in figure 5.



Effect of Tree Placement and Plot Aspect on Dogwood Anthracnose Disease Severity and Dogwood Reporduction

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Dogwoods along the Blue Ridge Parkway in Virginia, the Cherokee National Forest in Polk County, Tennessee, and Lookout Mountain in Tennessee were examined for dogwood anthracnose symptoms and reproductive potential. Tree locations were examined for factors that might affect disease severity. For each tree, disease severity, reproduction, and tree-placement data were recorded. At each location, plot aspect and elevation data were collected. Tree placement was determined as the tree being in a sunny or shady location. Disease severity was estimated by the following scales:

Mielke-Langdon Scale

Healthy tree	= 5
Diseased foliage:	
1-25%	= 4
26-50%	= 3
51-75%	= 2
76-100%	= 1
Dead tree	= 0

Modified Barratt-Horsfall Scale

Healthy tree	= 0
Canopy diseased:	
< 3%	= 1
< 6%	= 2
< 12%	= 3
< 25%	= 4
< 50%	= 5
< 75%	= 6
< 87%	= 7
< 93%	= 8
< 96%	= 9
100%	=10
Dead tree	=11

Percentage of the canopy that was dead was estimated using the modified Barratt-Horsfall (HB) Scale. HB ratings were converted to either percentage of diseased foliage or canopy or percentage of canopy dead using conversion tables developed by Redman and others (1). Reproduction was estimated for each tree using the following scale:

0 = no seedlings, berries, or viable flower buds

1 = a few berries or viable flower buds in one portion of the canopy

2 = berries or viable flower buds scattered in trees, and/or a few seedlings around tree

3 = heavy berry or flower bud set and/or many seedlings around tree

Results

Along the Blue Ridge Parkway, tree placement affected the amount of diseased foliage (fig. 1), disease severity (fig. 2), the amount of the canopy that had died (fig. 3), tree death (fig. 4), and tree reproduction rate (fig. 5) at most plot locations. Trees in sunny locations were less likely to be severely impacted by dogwood anthracnose as were trees in deep shade. A reduction in reproduction rates in shady locations was attributed to dogwood anthracnose, but trees located in sunny locations usually are more prolific bloomers than trees in deep shady areas (personal observation).

In Cherokee National Forest, plot aspect and elevation affected disease severity (fig. 6), the amount of canopy that was diseased (fig. 7), and dogwood reproduction rate (fig. 8). Trees located at higher elevations were more severely impacted by dogwood anthracnose than were trees at lower elevations. In plots located at less than 460 m, plot aspect had a significant affect on disease severity and percentage diseased canopy. At higher elevations, the disease was so severe that aspect effects on disease severity and percentage of diseased canopy were less apparent, but still statistically significant. Dogwood reproduction was significantly greater in plots with a south to west aspect at lower elevations (< 460 m) than in plots with a north to east aspect (> 460 m). However, at high elevations, aspect effects on reproduction were not significantly different.

At Lookout Mountain, tree placement and plot aspect affected disease severity (fig. 9) and reproduction rate (fig. 10). Plot elevations ranged from 500 to 624 m. Unlike the data collected in the Cherokee National Forest, aspect effects were significant at high elevations (above 460 m). Plots at Lookout Mountain were in urban habitats unlike the forest habitats in Polk County. Disease severity scores were less at the higher disease pressure at Lookout Mountain (when compared with plots above 460 m in Polk County), which may explain why dogwood reproduction was higher at Lookout Mountain.

Literature Cited

1. Redman, C.E., King, E.P., and Brown, I.F., Jr. 1969. Tables for conversion of Barratt-Horsfall rating scores to estimate mean percentages. Mimeo, unnumbered. Elanco Products Co., Indianapolis, IN.

Figure 1–Effect of tree placement on percentage of tree canopy displaying anthracnose symptoms (estimated using Barratt-Horsfall scale) at five locations along the Blue Ridge Parkway. At each placement site 10 trees were examined. For each column pair, * indicates that means differ according to two sample t-tests ($p = 0.05$).

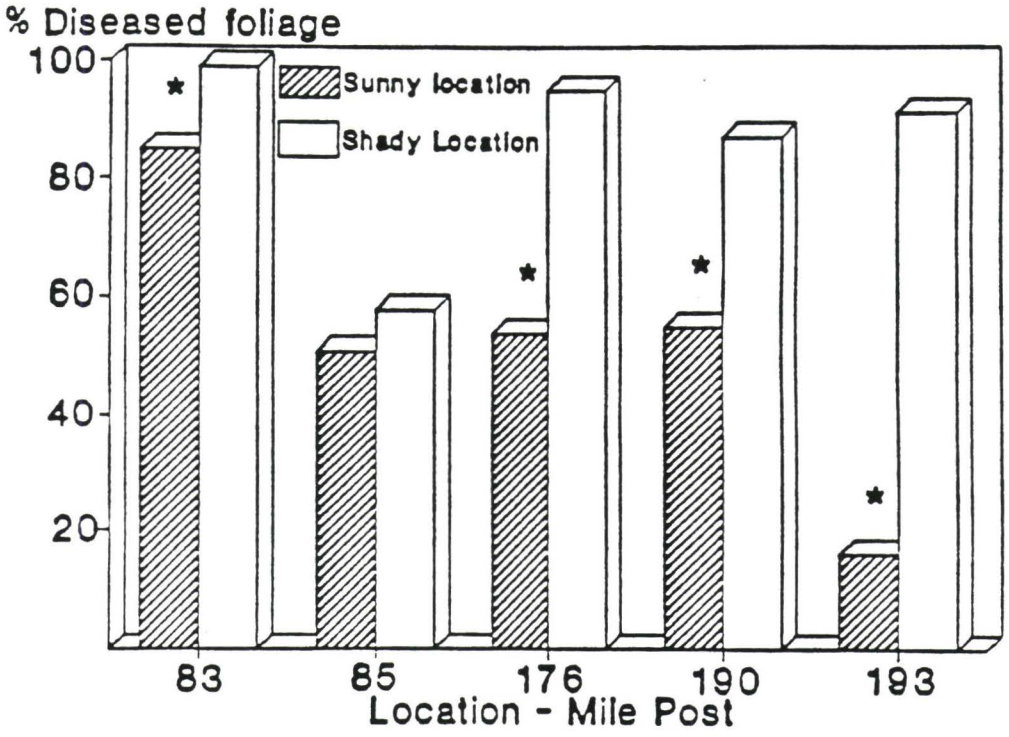


Figure 2–Effect of tree placement on anthracnose symptom severity (estimated with Mielke-Langdon scale) at five locations along Blue Ridge Parkway. At each placement site, 10 trees were examined. For each column pair, * indicates that means differ according to two sample t-tests ($p = 0.05$).

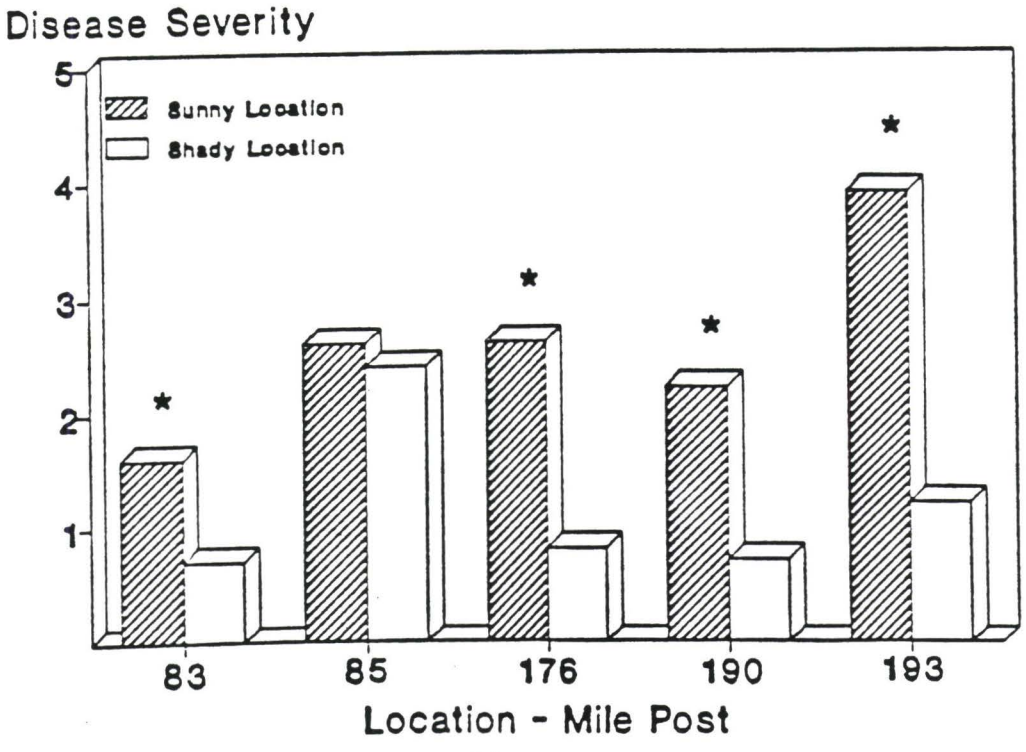


Figure 3-Effect of tree placement on tree canopy death at five locations along the Blue Ridge Parkway. At each tree placement site, 10 trees were examined. For each column, * indicates that means differ according to two sample t-tests (p = 0.05).

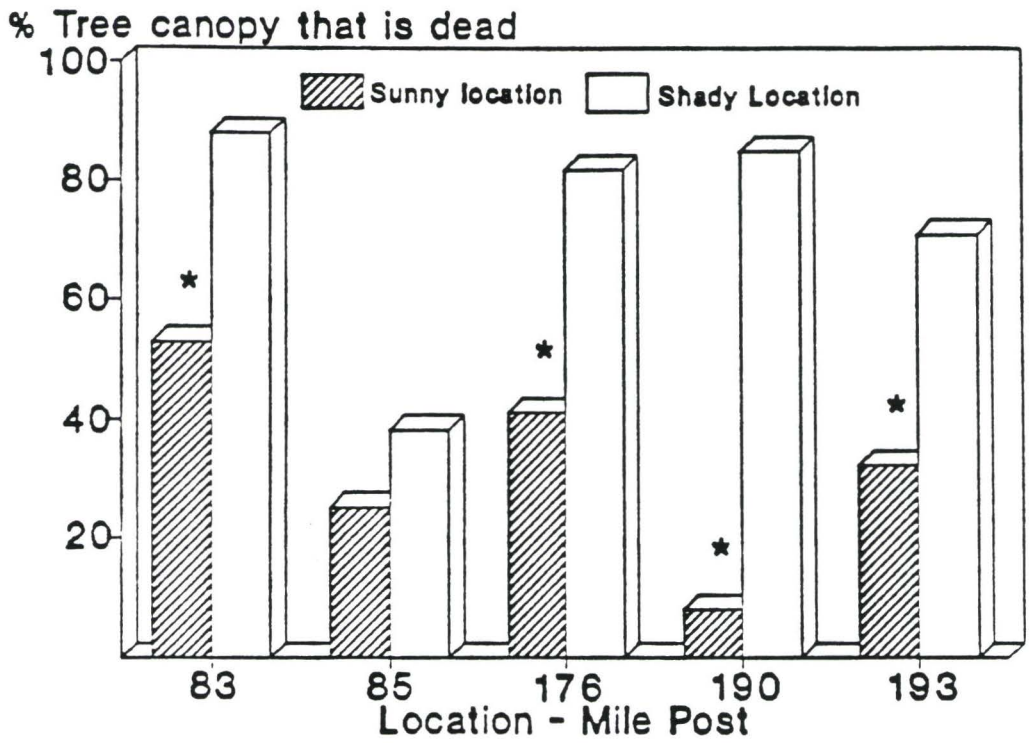


Figure 4-Effect of tree placement on tree death attributed to dogwood anthracnose. At each tree placement site, 10 trees were examined. For each column pair, * indicates that means differ according to two sample t-tests (p = 0.05).

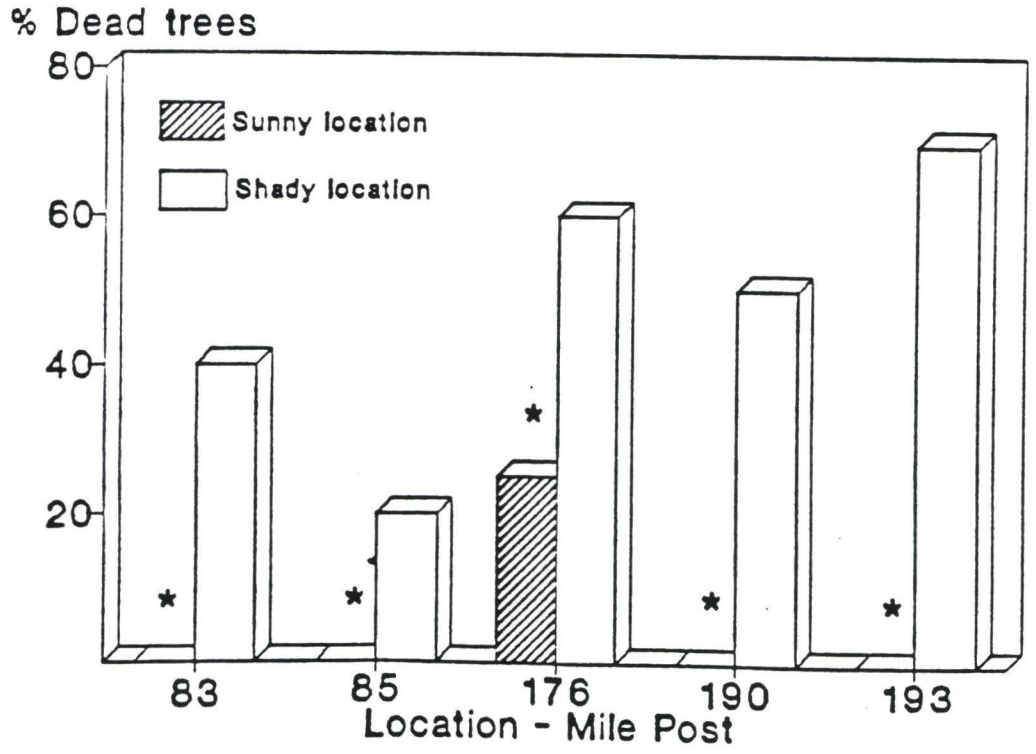


Figure 5–Effect of tree placement on reproduction rate at five locations along the Blue Ridge Parkway. At each placement site, 10 trees were examined. For each column pair, * indicates that means differ according to two sample t-tests (p = 0.05).

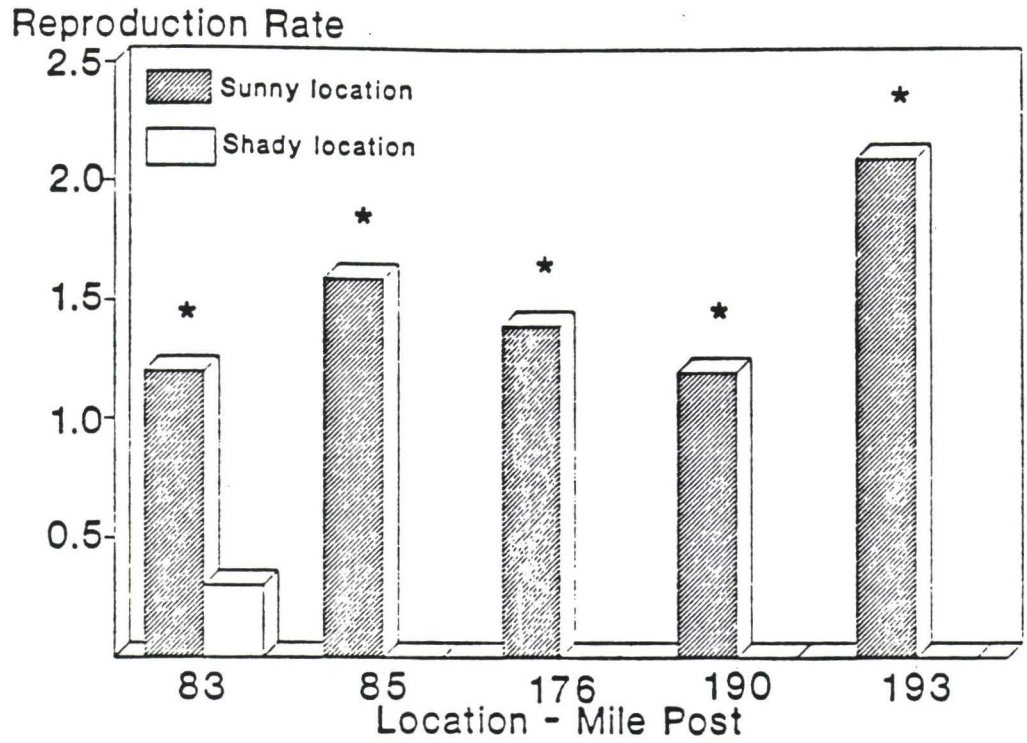


Figure 6–Effect of plot aspect and elevation on anthracnose symptom severity (estimated with Mielke-Langdon scale) in Cherokee National Forest. Means are for 10 trees in 14 plots for each elevation class. Bars represent standard error of the mean.

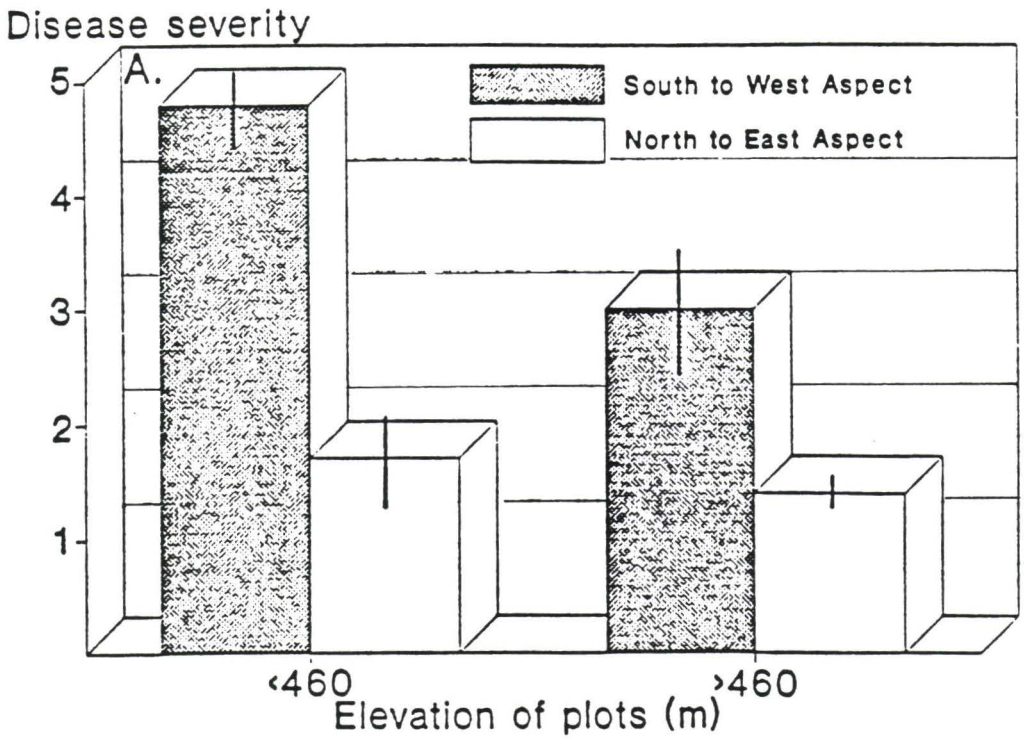


Figure 7-Effect of plot aspect and elevation on percentage of canopy displaying anthracnose symptoms (using Barratt-Horsfall scale) in Cherokee National Forest. Means are for 10 trees in each of 14 plots for each elevation class. Bars represent standard error of the mean.

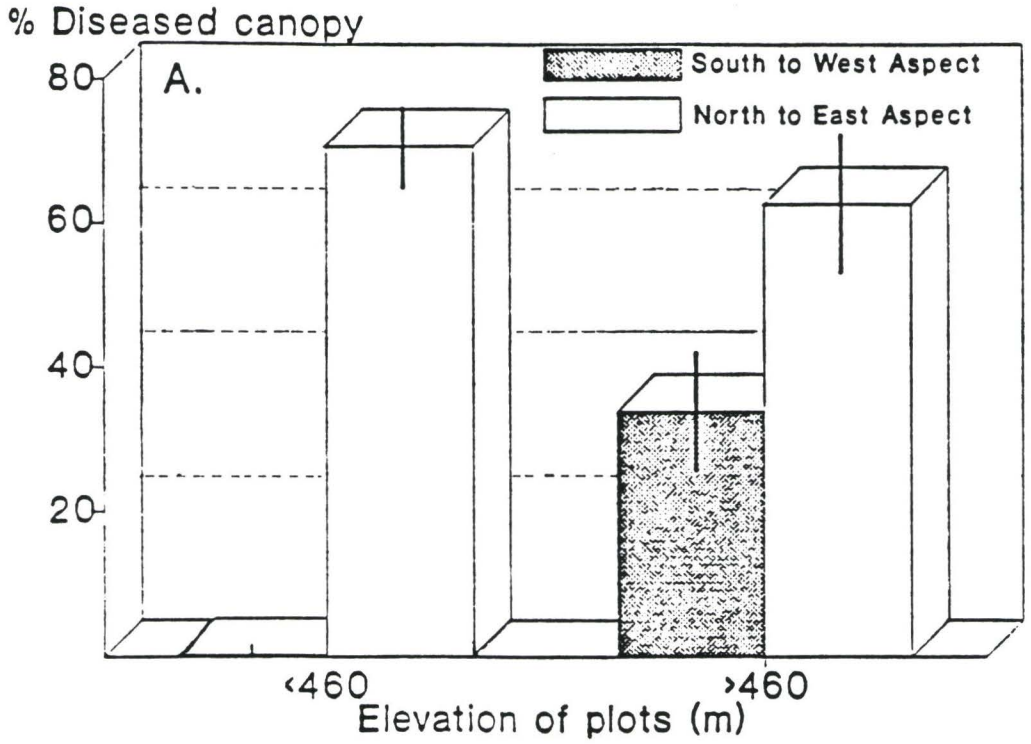


Figure 8-Effect of plot aspect and elevation on reproduction rate in Cherokee National Forest. Means are for 10 trees in each of 14 plots for each elevation class. Bars represent standard error of the mean.

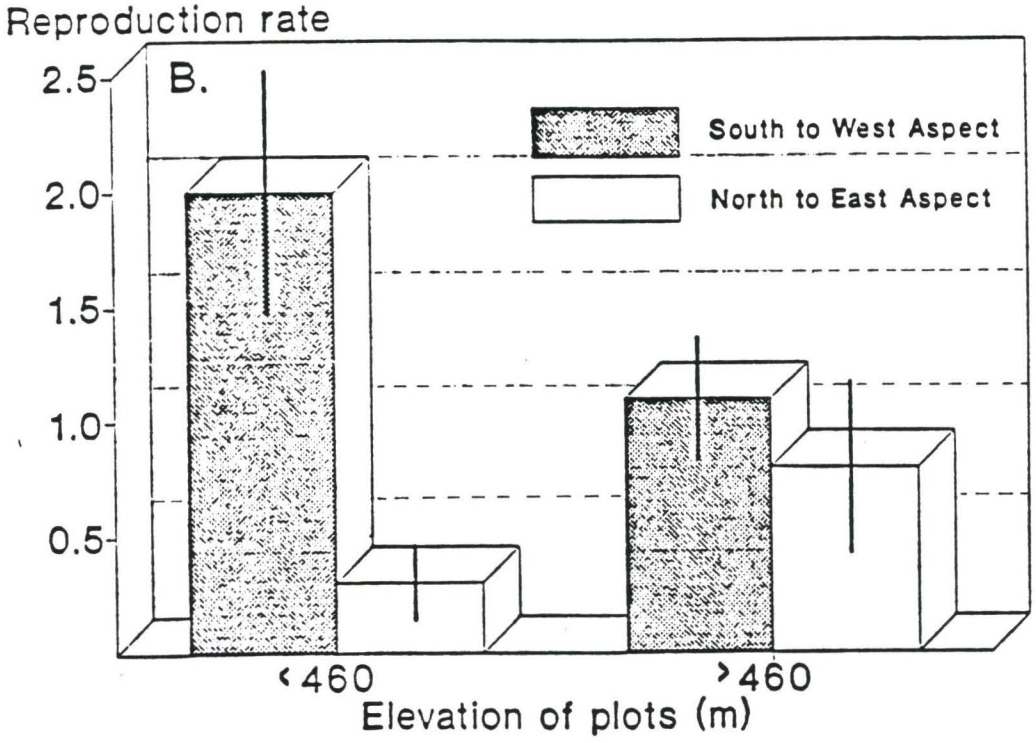


Figure 9-Effect of tree placement and aspect on anthracnose disease severity (estimated with Mielke-Langdon scale). Means are for 10 trees in each of 5 plots at Lookout Mountain in Tennessee. Bars represent standard error of the mean.

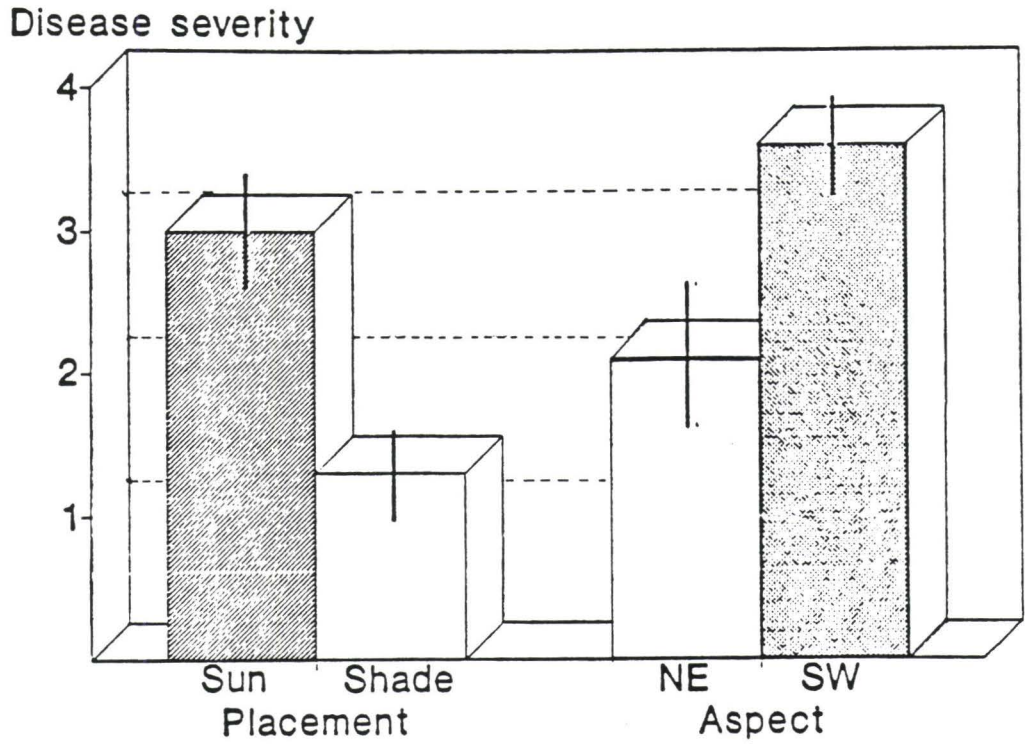
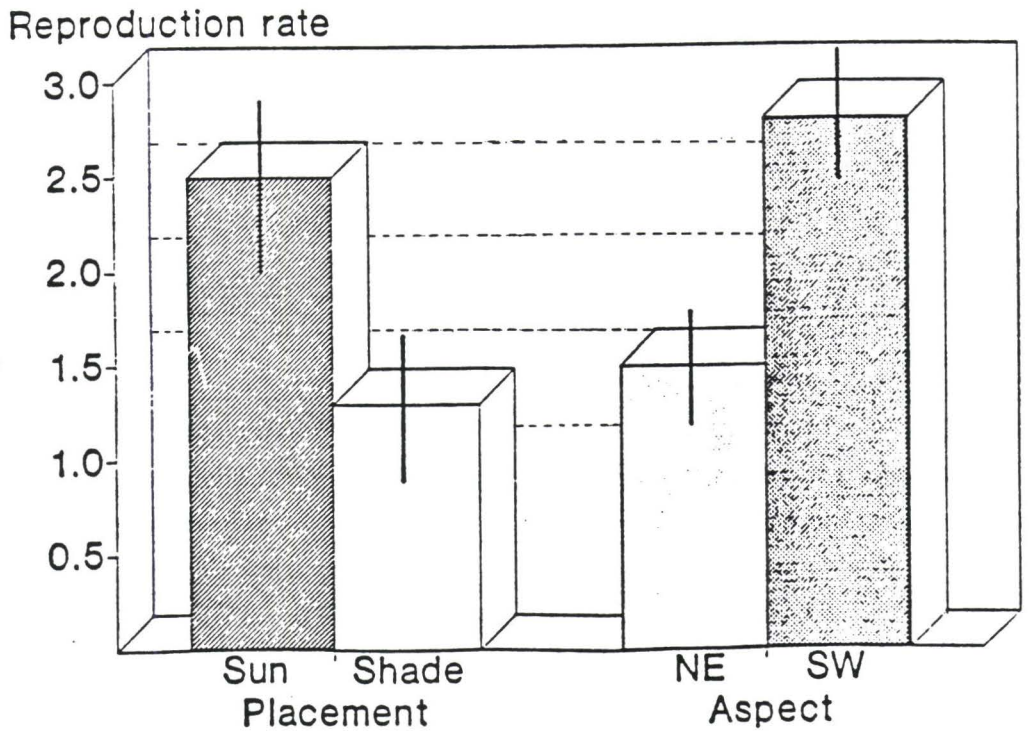


Figure 10-Effect of tree placement and aspect on dogwood reproduction. Means are for 10 trees in each of 5 plots at Lookout Mountain in Tennessee. Bars represent standard error of the mean.



Report #92-1-03

Effectiveness of Cultural Techniques, With Emphasis on Fertilization, to Control Dogwood Anthracnose

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Abstract

Ornamental dogwood trees at the Bent Creek Experimental Forest in Asheville, NC, were treated with different cultural techniques. All treated trees were pruned, mulched, and sprayed for dogwood borers. In addition, some trees received nitrogen, phosphorus, lime, or a balanced fertilizer or were watered during dry periods in 1990. Check trees received none of the treatments. These trees received only pruning, mulching, and dogwood borer control in 1991. Watering was not needed in 1991. All trees were scored for disease symptoms on a score from 100 to 0, most severe to healthy, respectively. All fertilizer treatments were correlated with reduced disease development. Nitrogen and phosphorous fertilization led to significantly lower disease ratings. It appears that any fertilization, especially with nitrogen and phosphorous, was beneficial in reducing disease severity.

Introduction

Dogwood anthracnose was found in the Northeastern United States in the late 1970's. The Northeast recommended a number of cultural control techniques for dogwood anthracnose. Since the South has a longer growing season and a variety of environmental conditions, Region 8, Forest Pest Management, began a pilot test in 1989 to evaluate these control recommendations under southern conditions.

At the Bent Creek Experimental Forest in Asheville, NC, a number of ornamental dogwoods became infected in 1989. The dogwoods were treated as recommended by the North, except no fungicides were applied. There were no prolonged dry periods in 1989, so watering was not needed. Five trees designated as checks received no treatment.

In 1990, the evaluation was continued and expanded to evaluate the effects of watering during dry periods or fertilization with high rates of nitrogen, phosphorus, lime, or a balanced fertilizer.

In 1991, the evaluation was continued with mulching, pruning, and dogwood borer treatments only.

Methods

All treated trees were pruned, mulched, and treated with Dursban for dogwood borer control in 1990 and 1991. Five trees were left untreated as checks. The following treatments were applied in the spring of 1990:

(1) Watering during prolonged dry periods, plus 10-20-10 fertilizer (rate:1.5 lb/diameter inch)
(2) Fertilizing with a high nitrogen (16-0-0) fertilizer (rate:3 lb/diameter inch)
(3) Fertilizing with a high phosphorus (0-46-0) fertilizer (rate:5 lb/diameter inch)
(4) Fertilizing with lime only (rate:200 lb/1,000 ft^2)
(5) Fertilizing with recommended fertilizer after soil analysis (10-20-10) (rate:1.5 lb/diameter inch)

Each treatment was replicated twice with three to six trees per replication. A buffer zone was left around each treatment to prevent different treatments from affecting each other. The fertilizer and lime were applied by broadcasting the material between the trunk and drip line. A soil analysis was made of each replication area before and at the end of the growing season in 1990.

The trees were rated for dogwood anthracnose in May, June, July, and August (1991) by finding the least affected and the most affected trees, which received scores of 0 and 100 percent, respectively. All other trees were fit on the scale from 0 to 100 percent by visual estimate.

Results and Discussion

Analysis of variance (table 1) revealed a significant difference among treatments at the 0.05 level of confidence. The high rates of nitrogen and phosphorus had the lowest amount of *Discula* sp. symptoms. The lime treatment, balanced and no treatment had the same severity of symptoms (table 2).

Basically, the data show that any type of fertilization coupled with the mulching, pruning, and dogwood borer control resulted in reduced dogwood anthracnose symptoms. Also, for some reason which is not fully understood, the nitrogen or phosphorous alone reduced the symptoms more than the lime or balanced. In 1991, the water treatment was the same as the balanced since we did not need to water the trees.

These data support the recommendation made in the "Growing and Maintaining Healthy Dogwoods" publication (1) that recommends fertilization according to a soil analysis.

Tests are underway with the University of Georgia and North Carolina State University to help clarify the rate and type of fertilization. It also needs to be reinforced that the other cultural practices such as pruning, mulching, and dogwood borer control are part of this integrated approach.

Literature Cited

1. **Bailey, Kenneth R. and Edward A. Brown II.** 1991. Growing and Maintaining Healthy Dogwoods, USDA Forest Service, Southern Region, Forestry Report R8-FR14.

Table 1--Analysis of variance for dogwoods treated with different types of fertilizers to assess the effects on dogwood anthracnose

Source of variation	Degrees of freedom	Sum of squares	Mean Squares	F	Probability
Among runs	11	5233.76	475.80		
Seedlots	5	4280.98	856.20	4.67 *	0.05
Runs	1	35.59	35.59	0.19	0.65
Seedlots x runs (experimental error)	5	917.19	183.44	0.32	0.89
Among replicate trays within runs (sampling error)	37	17043.04	460.62		
Total	48	22276.80			

Repeatability = 0.79

* Statistically significant at the 0.05 level.

Table 2--Duncan's multiple range test for different treatments imposed on dogwoods infected with Discula sp.

Seedlot	Test mean	Duncan's multiple range on seedlot test means
High phosphorus	5	*
High nitrogen	5	*
Water during drought	14	* *
Lime	18	* *
Balanced (NPK)[1/]	19	* *
No treatment	29	*

[1/] N = nitrogen, P = phosphorus, K = potassium.

Dogwood Anthracnose
Progress Report - 1991

Effect of Nitrogen and Phosphorus Fertilization on Infection and Disease Development

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University of Georgia

The field study established in 1990 at the Georgia Mountain Experiment Station in Blairsville, GA, was continued in 1991. Nitrogen and phosphorus (alone and in combination) were applied to attain medium and high soil fertility recommended for dogwood growth. Soil tests conducted at the University of Georgia Soil and Plant Testing Laboratory indicated that nitrogen was in the low range and P in the medium fertility range. Since calcium was in the very high range, we omitted this nutrient from the study. On April 24, we applied 150 lb/A ammonium nitrate and 110 lb/A super phosphate to obtain high N and P fertility. Plots not fertilized were considered to have medium N and P fertility. On May 15, an additional 150 lbs of ammonium nitrate was applied to the high nitrogen plots. Each treatment (total of four) contained four trees per replicate and was replicated 10 times in a completely randomized design. The trees were irrigated approximately two times a week to promote anthracnose development, and all trees were artificially inoculated in mid-April and mid-June. Trees were observed once a month and final readings were taken on September 23. Very little dogwood anthracnose was observed. Instead, we detected extensive development of spot anthracnose and septoria leaf spot. We intend to continue this study in 1992 with the addition of shade cloth to promote anthracnose development.

PROGRESS REPORT
(1991)

A Cooperative Pilot Test to Determine the Effects of Media pH, Fertilization Rates, and Moisture Stress on the Infection by the Dogwood Anthracnose Fungus (*Discula* sp.) on Flowering Dogwood, *Cornus florida* L.

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C. Ray Campbell
North Carolina Agriculture Agronomic Division

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USDA Forest Service

Abstract

Three hundred and thirty budded dogwood plants were potted in 3 pH levels (5.5, 6.0, and 6.5) and fertilized weekly with 3 levels of nitrogen (50, 100, and 200 p/m N). There was also a high phosphorous and a moisture stress treatment. There were two artificial inoculations with natural inoculum in the field locations. Only one of the six replications had significant infection. In that one replica, the higher nitrogen treatment had a higher infection level. All treated plants looked healthier than the other dogwoods in the area.

Methods

About 500 budded dogwood liners were potted in 3-gallon pots. The study used the most uniform 330 seedlings. The plants were potted and maintained at the Mountain Horticultural Crops Research and Extension Center (MHCREC) facilities in Fletcher, NC, until the leaves expanded. All treatments were established at this time. After the leaves were expanded and the 330 seedlings were chosen, the plants were moved to the USDA Forest Service facilities at Bent Creek, NC.

Three pH levels (5.5, 6.0, and 6.5) (table 1) were established in the container media by applying limestone. The plants were fertilized weekly with 3 levels of nitrogen (50, 100, and 200 p/m N) (table 1). There was a high phosphorous and a moisture stress treatment using the pH 6.0 and 100 p/m N as the control. The test design consists of five plants per treatment in each of the six locations for a total of 330 plants.

The Forest Service staff watered the plants (as needed) and assisted the MHCREC staff in fertilizing the plants once they were moved to Bent Creek.

At the same time the plants were growing at MHCREC, the dogwood anthracnose fungus (*Discula* sp.) was being cultured in the Forest Service laboratory to produce conidia for inoculum to inoculate the dogwood seedlings. Two artificial inoculations were made.

Foliar nutrient analysis were conducted on the plants on three sample dates beginning when the leaves expand in May.

MHCREC furnished its facilities, and planned and supervised plant maintenance (potting, fertilizing, watering regimes, etc.). The Forest Service furnished its facilities, and planned and supervised dogwood anthracnose fungus procedures (isolate, grow conidia, etc.), inoculations, and readings. Foliar nutrient analysis was done by the North Carolina Agriculture Agronomic Division Laboratory.

Results and Discussion

All treated trees looked healthier than the dogwoods growing wild in the area. Only one of the six replications had significant infection, even though all the overstory trees were severely infected. In that one replication, the higher nitrogen treatment was the most severely infected. In the moisture stress treatment, moisture was absorbed through the bottom of the pot.

The fertilizer treatments and project design will be modified in 1992, and the study will be repeated.

Table 1--Dogwood anthracnose treatment table

Treatment	pH	N rate (p/m)	P rate (p/m)
1	5.5	50	30
2	5.5	100	30
3	5.5	200	30
4	6.0	50	30
5	6.0	100	30
6	6.0	200	30
7	6.5	50	30
8	6.5	100	30
9	6.5	200	30
10	6.5	100	60
11	6.0	100	30

Control of Dogwood Anthracnose With Fungicide Treatments at Two locations in Tennessee

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Twelve fungicide treatments, plus an untreated control, were evaluated at two locations, Roaring Fork Creek in the Great Smoky Mountain National Park (GSMNP) and Ozone, TN. Fungicide treatments, rates, and application intervals are given in table 1. A spreader-sticker (Triton B-1956) was added to each fungicide solution/suspension at a rate of one drop/3.78 L. Experiments were started on May 2 at GSMNP and on May 8 at Ozone. Fungicide applications were continued till the end of August.

Each fungicide treatment was sprayed to run off on seven potted dogwood trees at each location. Dogwood trees were approximately 1 m high. At each location, seven naturally propagated trees with severe anthracnose symptoms were selected to serve as inoculum sources. The potted trees were arranged in a randomized block design with seven reps. One tree of each fungicide treatment and one control tree was placed underneath each one of the source trees.

Disease severity was estimated for each fungicide treatment and the control using the Mielke-Langdon scale. Data were analyzed using the Proc GLM procedure of SAS. Duncan's multiple range test was used to separate treatment means.

Results

Fungicide treatments were effective in reducing disease severity at both locations (table 2). Phytotoxicity symptoms were observed only after applying Banner at concentrations of 0.31 mL/L (mild leaf distortion, leaf distortion, and silvery appearance of leaves) and 0.63 mL/L (necrotic flecking, leaf distortion, and silvery appearance of leaves). These symptoms were more severe on trees at GSMNP than on trees at Ozone. Phytotoxicity symptoms in trees sprayed with 0.31 mL/L Banner were barely distinguishable at both locations.

High rates of Banner and Lynx gave control when applied at 4-week intervals. If the time between applications could be lengthened, treatments by homeowners might become more practical and less costly. More research in this area is needed.

Table 1--List of fungicides, rates used, and application intervals used at two sites (Roaring Fork Creek in the Great Smoky Mountain National Park and at Ozone, TN)

Fungicide treatment	Concentration (per liter)	Interval (weeks)
ASC 66719	2.3 g	2
Banner 1.1 E	0.16 mL	2
Banner 1.1 E	0.31 mL	2
Banner 1.1 E	0.63 mL	2
Banner 1.1 E	0.63 mL	4
Benlate 50 DF	1.2 g	2
Bravo 720	2.4 mL	2
Dithane DF	1.8 g	2
Lynx	2.0 mL	2
Lynx	6.0 mL	4
SAN 619	0.3 g	2
Systhane 2 EC	0.32 mL	2

Table 2--Effectiveness of fungicidal treatments at Roaring Fork Creek in the Great Smoky Mountain National Park and at Ozone, TN

Fungicide treatment	Disease severity*			
	GSMNP		Ozone	
	6/25	8/21	6/27	8/23
ASC 66179	4.8a	4.0a	4.6ab	3.8a
Banner 0.16 mL	5.0a	4.2a	4.7ab	4.0a
Banner 0.31 mL	4.9a	4.0a	4.4a	4.0a
Banner 0.63 mL/2 wk	4.9a	4.4a	4.3ab	4.3a
Banner 0.63 mL/4 wk	4.2a	3.8a	4.0ab	3.7ab
Benlate	4.8a	4.0a	4.4ab	4.4a
Bravo	4.4a	3.9a	4.3ab	4.1a
Dithane	4.8a	3.6ab	4.4ab	3.9a
Lynx 2 mL	4.9a	4.3a	4.3ab	4.2a
Lynx 6 mL	5.0a	3.8a	4.5ab	3.7ab
SAN 619	4.9a	4.0a	4.4ab	4.0a
Systhane	4.7a	3.7ab	4.5ab	3.5ab
Control	4.0a	2.4 c	3.8 b	2.6 c

*Disease severity was estimated using Mielke-Langdon scale where 5 = healthy, 4 = 1-25%, 3 = 26-50%, 2 = 51-75%, 1 = 76-100% diseased foliage, and 0 = dead tree.

abc for each column, means followed by the same letter do not differ according to Duncan's multiple range test (0 = 0.05).

Dogwood Anthracnose
Progress Report - 1991

Evaluation of Fungicide Foliar Sprays and Trunk Injections on Control of Dogwood Anthracnose

R.W. Roncadori and F.F. Hendrix
University of Georgia

This study was established in the Duke's Creek Falls area of the Georgia Mountains where the disease has been epidemic. Foliar sprays were applied to both leaf surfaces until runoff using a backpack sprayer. Applications were begun on April 2 and continued on a 2-week schedule, unless otherwise indicated, until June 12 (6 sprays). Treatment 5 consisted of Lynx on a 2-week schedule with the fifth spray omitted to provide a 1-month interval. Treatments are listed in the attached table and each was replicated four times in a completely randomized design.

Trunk injections were completed on May 1 and included the fungicides listed in the following table. Injections with the Mauget instrument (4 mL/injector) were placed 12 cm apart near the root flare. Two Aliette injections (20 mL formulation/site) were made per tree opposite each other. Trees in this study ranged from approximately 7.5 to 15.0 cm d.b.h. Each treatment was replicated four times in a completely randomized design.

Disease assessments were based on estimated percentages of individual leaves with necrosis, on a scale of: 0 = no symptoms, 1 = trace to 5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100%, and 6 = leaf abscised. Twenty-five leaf pairs in the lower crown of each tree were rated on May 29 and July 3, 1991. Data were analyzed by analysis of variance and means separated by the Duncan's multiple range test, $P = 0.05$.

Significant disease control occurred with both foliar sprays and trunk injections (see table). Although all foliar sprays effectively reduced leaf infection, best results were obtained with Lynx, Asc 66825, and Benlate. Trunk injection was relatively ineffective compared with foliar sprays. Control was provided by Lynx, Aliette, and Arbotect injections.

Dogwood Anthracnose Fungicide Tests
1991

	Treatment/Rate*	Disease rating 5-29-91	Disease rating 7-3-91
	Spray treatments		
1.	Control	2.585 A**	2.665 A
2.	Daconil 5.7 g/gal	1.485 B	1.320 B
3.	Benlate 4.6 g/gal	1.130 C	0.750 E
4.	Lynx 3.0 mL/gal	0.890 D	0.815 D
5.	Lynx 3.0 mL/gal	0.615 F	0.470 G
6.	Asc 66825 4.5 g/gal	0.270 G	0.500 F
7.	Asc 66825 9.0 g/gal	0.880 E	0.835 C
	Mauget Tree Injectors		
9.	Arbotect	2.3300 C	2.1850 C
10.	Lynx	2.440 C	1.9550 D
11.	Plant Vax	2.2700 C	2.6000 B
12.	Plant Vax & Arbotect	3.0150 B	3.1800 A
13.	Control	3.3050 A	2.7750 B
	Syringe Injectors		
8.	Aliette	1.5632 B	1.3550 B
14.	Control	2.5800 A	1.6400 A

* = Formulated rate

Aliette	- 9.5% a.i.
Arbotect	- 2.0% a.i.
ASC 66825	- 50 WP
Benlate	- 50% DF
Daconil 2787	- 90 DG
Lynx	- 2 F
Plant Vax	- 2.0% a.i.

** = p = 0.05 Duncan's multiple range test

Report #91-1-43

Development of an Inoculation System for Infection of Flowering Dogwoods With *Discula* sp. at the Resistance Screening Center, 1991

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Abstract

Several systems for screening dogwood seedlings for resistance to *Discula* sp. were evaluated at the Resistance Screening Center. The system yielding the best results was an open-field area covered by shade cloth and misted to maintain high humidity. The inoculation procedures consisted of suspending infected branches over the seedling and spraying spore suspensions onto seedlings.

Introduction

Dogwood anthracnose, caused by *Discula* sp., was discovered in the United States in the late 1970's. It has since killed millions of trees. After 4 years of monitoring in the Southeastern United States, presence of the disease has been confirmed in 120 counties in 7 Southern States. It is estimated that over 6 million acres are affected. In some areas, dogwood mortality is 100 percent.

Occasionally, a tree is observed that may be resistant to the fungus. However, no operational procedures exist to assess the potential resistance. The Southern Region of the USDA Forest Service is interested in screening dogwood selections across the region for potential resistance. Identification of such resistance could be the first step in establishment of a seed orchard of resistant dogwood. The Resistance Screening Center in Asheville, NC, and the Southeastern Forest Experiment Station were asked by the Southern Region to develop an operational screening procedure.

This report presents the results of the 1991 field season at the Resistance Screening Center.

Methods

Germinating dogwood seedlings (about 2 inches tall) were transplanted into 1-L containers filled with metro-mix. These seedlings were maintained in a greenhouse. An additional group of seedlings was germinated in sand and transplanted into a flat of metro-mix.

There were several inoculation procedures:

1. Woods Inoculation - One-inch PVC pipe was used to make a rack 4 feet tall, 4 feet wide, and 8 feet long. A plastic screen was installed on the top to hold infected leaves and branches, and the system was placed in full shade in the woods. Six-inch-tall seedlings in the 1-L pots were placed about 6 inches apart on the ground in the system. Infected leaves and branches were suspended about 3 feet over the seedlings. One-half of the seedlings were inoculated with a spray of 2,000 spores per mL applied 1 day after placement in the woods.

2. Open-Field Inoculation (6-inch-tall seedlings) - One-inch PVC pipe was used to construct a frame 5 feet wide, 6 feet tall, and 61 feet long. A plastic rack was installed 3 1/2 feet from seedling tops to suspend infected leaves and branches. Misting nozzles were installed above the infected leaves to inject a penetrating fog and mist through the infected branches. In addition, a backup watering system was added below the infected leaves. The whole system was then covered with shade cloth to provide 73 percent shade. Six-inch-tall seedlings in 1-L pots were placed on the ground about 6 inches apart. One-third of the seedlings had only infected branches suspended over them. One-third had the infected branches plus artificial inoculation at 2,000 spores per mL. The remaining third received artificial inoculations only.

3. Open-Field Inoculation (2-inch-tall seedlings) - Two-inch-tall seedlings were grown in metro-mix about 2 inches apart in a tray measuring 2 feet by 2 feet. This tray was placed in the system described in number 2. The seedlings were artificially inoculated at the rate of 2,000 spores per ml 1 day after placement in the system.

Seedlings in the woods inoculation study received no moisture treatments, whereas all seedlings in the open-field study did. Moisture was applied by misting daily from 10 a.m. to 5 p.m. (unless it was raining).

All seedlings were checked weekly for symptom development. The seedlings were inoculated on June 21 and read on July 20. Each tree was examined for (1) infection, (2) percent of the leaves showing symptoms, (3) percent of the leaf area affected for the symptomatic leaves, and (4) percent of leaf area affected for the most severely affected leaf on the seedling. Twenty leaves were picked from each treatment and checked to ensure that *Discula* sp. was present in the symptomatic tissues. General observations were made on seedling condition.

Results and Discussion

After 30 days, symptoms had developed enough to be read. Percentages of seedlings affected, leaves affected, leaf area affected for symptomatic leaves, and leaf area affected on the most severely affected leaf on a seedling are shown in table 1. All of the techniques provided useful information. The woods-treated seedlings had very light infection, which would make it difficult to estimate seedling susceptibility. The open-field 3-inch seedlings provided good information, but often had only 4 to 6 small leaves–too few for adequate seedling separation. The open-field artificial inoculations gave the lowest infection in the field, while open-field natural and open-field artificial plus natural inoculation gave only slightly better results. Most of the seedlings became infected. About 50 percent of the leaves on the seedlings were symptomatic, and about 20 percent of the leaf area was affected on the symptomatic leaves. The percentage of area symptomatic on the most severely affected leaf per seedling was rejected because of a large variability.

Based on this 1 year's data, we are recommending the use of open field with shade cloth and using natural plus artificial inoculation. Clearly, the system can be improved. We plan on trying double shading and pre-inoculation in a chamber next year.

The Southern Region has been contacted and hopes to begin inoculating seed selections next year. Any selections showing resistance could be propagated and subjected to additional testing.

Table 1--Percentages of dogwood seedlings and leaves per seedling expressing dogwood anthracnose symptoms after inoculation

Procedure	Seedling height	Seedlings affected	Leaves affected/plant[1/]	Leaf area affected on symptomatic leaves[1/]	Area of most severely affected leaf per plant
	Inches	- - - - - - - - - - - - - - - - - -		Percent	- - - - - - - - - - - - - - - - - -
Woods:					
Natural inoculation	6	69	14.8/12.8	1.6/1.6	Not taken
Artificial and natural inoculation	6	88	15.9/11.3	4.4/4.3	Not taken
Open Field: (Shade cloth)					
Artificial Inoculation	3	100	56.8/12.9	27.8/11.1	51.4/18.3
Artificial Inoculation	7	92	29.8/16.9	4.7/4.4	15.4/22.4
Artificial and natural inoculation	7	100	64.4/15.2	20.0/7.9	49.4/25.8
Natural inoculation	7	92	47.5/16.0	17.2/8.9	47.3/28.2

[1/] First number is the average and second is the standard deviation.

Results of the 1990 Dogwood Anthracnose Impact Assessment and Pilot Test in the Southeastern United States

Protection Report R8-PR 20

United States Department of Agriculture
Forest Service - Southern Region
Forest Pest Management
Asheville, North Carolina

August 1991

Contents

	Page
Contributors	2
Pesticide Precautionary Statement	4
Background	5
Literature Cited	9
Summary	10
Agencies That Participated in the Impact Assessment and Pilot Testing	12
Report Summaries	13
Individual Studies	
Distribution of Dogwood Anthracnose in the Southeastern United States - December 1990	17
Dogwood Anthracnose Impact Assessment in the Southeast - 1990	25
A Preliminary Hazard Rating for Dogwood Anthracnose in the Southern Appalachians	34
Effectiveness of Cultural Techniques to Control Dogwood Anthracnose	39
Residual Effects of Control Strategies Applied in the Previous Year	44
Use of Fungicial Sprays and Pruning to Control Dogwood Anthracnose in a Nursery Field	47
Dogwood Anthracnose Studies	49
Chemical and Cultural Control of Dogwood Anthracnose at Lookout Mountain National Park	57
A Pilot Test of the Fungicide Lynx Used as a Soil Drench to Control Dogwood Anthracnose	60
A Pilot Test of the Fungicide Banner Used as a Soil Drench to Control Dogwood Anthracnose	64
Evaluation of Growth Retardant for Epicormic Shoot Control on Flowering Dogwoods	68
Epicormic Shoot Dieback of Flowering Dogwood Caused by *Discula* sp. During Dormancy	69
Correlation Between Simulated Acid Rain and Dogwood Anthracnose in the Greenhouse	70

Results of the 1990 Dogwood Anthracnose Impact Assessment and Pilot Test in the Southeastern United States

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Pesticide Precautionary Statement

This publication reports pilot testing involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

BACKGROUND

Dogwood anthracnose is a disease of flowering and Pacific dogwood, (Cornus florida L. and C. nuttallii Audubon). Infection of Pacific dogwood has been reported from Washington, Oregon, Idaho, and British Columbia. In the South, infections have been reported on flowering dogwood in Virginia, North and South Carolina, Tennessee, Georgia, Kentucky, and Alabama.

Infection of dogwoods is favored by cool, wet spring, and fall weather but can occur throughout the growing season. Drought and winter injury weaken trees and may increase disease severity. Consecutive years of heavy infection have resulted in extensive mortality of both woodland and ornamental dogwoods. The origin of this disease is unknown, but it is suspected to have been introduced.

Dogwood anthracnose was first reported in 1978. It was causing a widespread, rapid deterioration of flowering dogwood in New York and Connecticut. In 1983, Daughtrey and Hibben (2) reported a lower branch dieback disease with the same symptoms on flowering dogwood in New York, Connecticut, New Jersey, and Pennsylvania. They made observations on trees in Planting Fields Arboretum, Oyster Bay, Long Island, and a woodland site at the Brooklyn Botanic Garden Research Center at Ossining, New York. They reported the cause of the disease to be a species of Discula. Daughtrey and Hibben (2) reported that the reason for a sudden onset of anthracnose over part of the northeastern range and its coincidental outbreak on western flowering dogwood was unknown. They speculated that climatic changes may have been a factor and that the disease may have been introduced. Hudler proposed that droughts or sudden changes in the environment may have predisposed the trees to infection (3). In 1984 a survey of dogwood anthracnose was made in Catoctin Mountain National Park. Mielke and Langdon in 1986 found that only 3 percent of the dogwoods were disease free, and that about one-third were dead (5). Schneeberger Jackson repeated the survey in 1983 and found that 89 percent of the dogwoods were dead, that there was almost no regeneration, and that all remaining trees were diseased (6).

Byther and Davidson described a similar disease on western flowering dogwoods in western Washington and named it dogwood anthracnose. The disease was reported in Oregon, Idaho, and British Columbia in 1983 (1). The casual organism was reported to be Discula. Daughtrey and Hibben compared the symptoms, signs, and organisms on the western flowering dogwood and the eastern flowering dogwood. They concluded that the same disease occurs in both areas. It was at this time that the disease on eastern flowering dogwood was named dogwood anthracnose (2). In 1985 Mielke and Daughtrey wrote a pest alert designed to help assess the distribution and spread (4). By 1987 the disease had been reported in over 60 counties in 9 Northeastern States (Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Virginia, and West Virginia). In the late 1970's and early 1980's there was considerable speculation as to whether dogwood anthracnose could successfully spread to the Southeastern United States. In October of 1987, unusual numbers of dogwoods were reported dying on the Cohutta Ranger District on the Chattachoochee National Forest in Northern Georgia. All of the symptoms matched those of dogwood anthracnose. Foresters estimated that the affected area covered about 30,000 acres of the Cohutta Wilderness. Discula, the casual organism of dogwood anthracnose, was isolated from samples from the affected area.

The National Forest Supervisor and State Forester of Georgia were notified of the occurrence. Soon thereafter, Bob Zahner, a professor from Clemson University, reported an unusual problem with the dogwoods in Cashiers, North Carolina. This area was checked and Discula was found. In this case, the affected area was much larger than the 30,000 acres found in Georgia. At this time, the State Forester of North Carolina was notified, and a meeting of State and Federal personnel from the affected and adjacent States was held in Dillard, Georgia, in February 1988. This group became a dogwood anthracnose working group and agreed that the top priority was to assess the disease distribution. The Southern Region of the Forest Service distributed a southern version of the dogwood anthracnose pest alert.

By the second meeting of the working group in May of 1988, the disease had been found in Georgia, North Carolina, South Carolina, Tennessee, and Virginia. It was reported that the disease affected trees of all sizes and was more common in the mountains and cool wet valleys. Six nurseries in North Carolina and one in South Carolina were reported to have diseased trees. Fungicide trials were started in Georgia and Tennessee, and a joint pilot test proposal was prepared for submission to the Washington Office. Coleman Doggett, North Carolina Pest Control Forester proposed that permanent plots be established on a 15-mile grid to assess the current and future impacts. These plots were installed by State and Federal personnel in each of the respective States. In June of 1988, the fungus had been found in so many locations that the USDA Forest Service and the University of Georgia began to provide sample identification services. In September the working group developed a news release, but it was decided not to send the release until more information was collected. After this point, the information became known to the press and public. As a result, the news release was never issued. The National Park Service did distribute a news release from the Great Smoky Mountains National Park. Dogwood anthracnose and its impact received major media coverage.

At this point, a lot of work was being done, and the working group concept was good, but the process was reactive and information was not being managed to assist in the process. The public was getting scarce information from the press, and politicians were responding to the problem without knowing the whole story. A third meeting of the dogwood anthracnose working group was held in October 1988. By this time, a funding proposal had been submitted to the Washington Office for consideration. The disease had been identified in 49 counties in the South, and 60 permanent plots had been established to assess impact. Birds were discussed as possible vectors, and fungicide studies in Georgia had not produced positive results. Fungicides had been applied in the late summer. One important concern was the inability to inoculate trees under controlled conditions. A high priority was placed on this task. In November of 1988, the Great Smoky Mountain National Park in cooperation with the University of Tennessee completed a survey of the Park and found the disease was widespread.

In January of 1989, the Regional Forester for the Southern Region of the USDA Forest Service called a meeting of the Federal and State cooperators to discuss dogwood anthracnose. At this meeting, a list of priorities was developed for survey, impact assessment, and research, and a dogwood anthracnose steering committee was developed to help with the biological and political aspects of the problem.

In March 1989, eight national forests were surveyed to assess the distribution. At the same time, a greenhouse inoculation test was completed with positive results. Anderson, Knighten, and Dowsett found when seedling leaves were pretreated with an acid mist, fungus spores routinely produced infections on them. Results led to a controlled acid rain study where a positive correlation was established between simulated acid rain and infection in the greenhouse. Funding was approved for a pilot test of control techniques, and several studies were started by the USDA Forest Service, the University of Tennessee, the University of Georgia, and the National Park Service.

In the spring of 1989, the media coverage picked up considerably. The story ran in dozens of newspapers and on radio and TV. CBS National News did a Saturday segment on the disease. Realizing the need to provide the best information possible to the public, the USDA Forest Service, the University of Georgia, and the State Forester of Georgia developed and published a booklet on how to manage dogwood anthracnose. To keep public officials informed, a briefing package was developed by the Forest Service. The package included a briefing paper and a list of people to be contacted. It was about this time that the correlation between simulated acid rain and dogwood anthracnose was released. Because of the interest in acid rain, major political problems arose as the information was released to the press. In 1990 the acid rain study was repeated and showed the same result. At this time, proposals for research and impact assessment were being submitted to the Washington Office. The Southeastern Forest Experiment Station assigned one person to work part time on the disease in 1989. By this time, the disease had been found in 57 counties in 7 Southern States.

By 1990 considerable information was accumulating. It was noted that the fungus seemed to remain active and grow down the shoots in the winter. The disease was more common at high elevations and in cool, wet coves was able to spread over large areas very quickly (81 counties now had diseased trees), and the fungus preferred cool temperatures. Pilot test data showed that the fungicides Benlate and Daconil were providing effective control and that other fungicides showed promise. Fertilization and mulching seemed to improve tree vigor, while not increasing the disease in the field. Other greenhouse and field tests were showing that phosphorus tended to increase and lime tended to reduce disease symptoms.

Nevertheless, we still knew very little about this complex problem. Early literature reported that there was no resistance in the native flowering dogwood populations, but people were noting some trees in the field that seemed to show resistance. Resistance became a high priority for research in 1990.

In September of 1989, the working group met again to discuss progress. Eighty-four counties were reported with diseased trees, and the impact plots showed the disease had increased from one-half million acres in 1988 to 2.2 million acres in 1989. The National Park Service announced that it would investigate mycological aspects of the problem. Forest Service research officials reported that they would be working on epidemiology.

In December 1989, Kerry Britton of the Southeastern Forest Experiment Station held a research planning meeting in Athens, Georgia. The Station had received funding for anthracnose research, and the purpose of the meeting was to develop a plan for the next 5 years.

Forest Pest Management recently evaluated a forest stand that had a major component of dogwood near Asheville, North Carolina. After about 3 years of infection, 42 percent of the dogwoods have died, the remainder are infected, and there is no regeneration. The disease is spreading rapidly, heavily impacting large areas.

In the fall of 1990, the Southern Appalachian Man and Biosphere Cooperative (SAMAB), consisting of the U.S. Environmental Protection Agency, Forest Service, Park Service, Southeastern Forest Experiment Station, Fish and Wildlife Service, Department of Energy, Economic Development Administration, and the Tennessee Valley Authority, organized two dogwood anthracnose conferences. One was held in Knoxville, Tennessee, and the other in Asheville, North Carolina. These conferences consisted of representatives from Federal, State, and private concerns, and featured speakers from a number of these agencies. The program reflected a diversity of views held by various groups throughout the South. These meetings increased the awareness of and understanding of dogwood anthracnose, and helped define specific goals, such as effective information dissemination.

Disease distribution has been difficult to determine. For any major pest problem, the first question is "Where is the disease found?" For this disease, incidence maps would be very useful. Since there are so many mimicking symptoms, it was decided that for a county to be called affected, presence of the disease had to be confirmed in the laboratory.

For impact assessment, some 210 permanent 10-tree dogwood plots have been established in North Carolina, South Carolina, Tennessee, Alabama, Virginia, Kentucky, and Georgia. These plots are on a 15-mile grid. Data gathered on the plots in 1988 and 1989 show that the disease increased dramatically (from about 1/2 million acres in 1988 to 2.1 million acres in 1989), and that severity on the permanent plots has increased. Obviously, the rapid increase in area and acreage reflects discovery of areas infected for some time, in addition to actual yearly increase. However, from observation of infection in fairly large geographic areas, it is clear that there was a major increase in the disease in 1989. In 1990 the plot data were entered onto a Geographic Information System in an attempt to produce maps showing severity as well as incidence.

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SUMMARY

By December of 1990, dogwood anthracnose had been found in 126 counties in 7 Southern States. The increase over 1989 in number of affected counties was 35 percent. About 5.7 million acres are estimated to be affected, and mortality is increasing. Preliminary work on hazard rating systems seems to show a correlation between disease severity and elevation. The higher the elevation, the more severe the damage to the dogwood resources. In addition, work by the Great Smoky Mountains National Park has shown a relationship between disease occurrence and aspect and proximity to water.

1. Select healthy trees to plant.
2. Purchase trees from a reputable nursery; do not transplant trees from the wild.
3. Select planting sites where foliage will dry rapidly in the morning and afternoons.
4. Use proper planting techniques.
5. Prune and destroy dead wood and leaves yearly; prune trunk sprouts in the fall.
6. Water weekly in the morning during droughts. Caution: Do not wet foliage.
7. Maintain 4- to-6 inch-deep mulch around trees; do not use dogwood chips as a mulch.
8. Fertilize according to soil analysis.
9. Use proper insecticide and fungicide where appropriate.
10. Avoid mechanical and chemical injury to trees.

The recommended cultural control techniques appear to be effective in reducing disease severity. General pruning seems to be of little value, but removal of epicormic shoots helps to prevent stem infection. Watering during drought is effective, but the watering must be done in the morning and not touch the foliage. Mulching helps by reducing moisture stress and reducing trunk wounding. All fertilizer treatments resulted in reduced infection when compared with the check. Nitrogen seemed to be most effective.

A number of fungicides were sprayed on foliage, injected into stems and used as soil drenches. No injections or drenches worked. Several fungicides worked as foliage sprays. Two registered fungicides, Benlate and Daconil, gave excellent control as foliage sprays. Other fungicides, such as Lynx, gave better control but are not registered for this purpose. A chemical, Maintain A, was tested to reduce epicormic shoot formation but it was translocated in the plant, producing undesirable effects.

A greenhouse test in 1989 showed a relationship between simulated acid rain and disease symptom development. This test was repeated in 1990 with the same results.

A 1991 dogwood anthracnose pilot test is planned. The test will: (1) track the distribution, (2) assess impact changes, (3) test fungicide spray schedules, (4) continue to assess the cultural control techniques, (5) refine the hazard rating, and (6) look at the possible fertilizer interaction.

AGENCIES THAT
PARTICIPATED IN THE
IMPACT ASSESSMENT
AND PILOT TESTING

USDA Forest Service - Forest Pest Management

Distribution of Dogwood Anthracnose
Cultural and Chemical Control Techniques
Simulated Acid Rain Correlation
Pruning Evaluation

University of Georgia

Chemical and Cultural Control Techniques
Pruning Evaluations

Great Smoky Mountains National Park

Hazard Rating
Chemical and Cultural Control

State Foresters' Offices - Alabama, North Carolina, South Carolina, Virginia, Georgia and Tennessee.

Distribution of Dogwood Anthracnose
Impact of Dogwood Anthracnose

REPORT SUMMARIES

The individual report section contains the detailed reports for each of the assessments and pilot tests. A brief summary of each report follows:

DISTRIBUTION OF DOGWOOD ANTHRACNOSE IN THE SOUTHEASTERN UNITED STATES - DECEMBER 1990

ABSTRACT

Since dogwood anthracnose was found in the Southeastern United States, people from State, Federal, and private concerns have helped track its distribution. To be added to the distribution map, a county must have diseased trees and have Discula sp. confirmed in the laboratory. By December 1990, 126 counties were classified in 7 Southern States as having infected trees.

DOGWOOD ANTHRACNOSE IMPACT ASSESSMENT IN THE SOUTHEAST - 1990

Two hundred and ten permanent dogwood plots have been established in dogwood anthracnose affected counties in Virginia, North Carolina, South Carolina, Georgia, Kentucky, Tennessee, and Alabama. These plots were selected as a random stratified sample on a 15-mile grid. The acreage affected in the Southeast was estimated at about 1/2 million acres in 1988, 2.2 million in 1989, and increased to 5.7 million acres in 1990. Mortality increased from 0 to 3 percent from 1988 to 1990 and the percentage of severely damaged trees increased from 4 to 11 percent.

PRELIMINARY HAZARD RATING FOR DOGWOOD ANTHRACNOSE IN THE SOUTHERN APPALACHIANS

Most dogwood anthracnose workers have recognized a difference in infection rates in different habitats when conducting field surveys. This study indicates that there is a significant difference across the landscape (in the park) that may be attributable to temperature and moisture changes that are, in turn, influenced by topography and distance from streams.

EFFECTIVENESS OF CULTURAL TECHNIQUES TO CONTROL DOGWOOD ANTHRACNOSE

Ornamental dogwood trees at the Bent Creek Experimental Forest in Asheville, North Carolina, were treated with different cultural techniques. All treated trees were pruned, mulched, and sprayed for dogwood borers. In addition, some trees received nitrogen, phosphorus, lime, or a balanced fertilizer, or were watered during dry periods. Check trees received none of the treatments. The trees were classified as being in full sun, in partial shade, or in full shade, and as high vigor, moderate vigor, or low vigor. There was no correlation between the sun position and disease severity. All fertilizer and the water treatments were correlated with reduced disease

development. Nitrogen fertilization had the lowest disease rating. It was also noted that watering in the afternoon increased disease symptoms and that cankers formed on the main stem if the epicormic shoots were not pruned.

DOGWOOD ANTHRACNOSE STUDIES
UNIVERSITY OF GEORGIA

Of the registered materials, Benlate and Daconil gave the best control of dogwood anthracnose leaf symptoms. Benlate was statically better, although both materials gave adequate control. Lynx, not registered for use on dogwood, was as effective as a foliar spray as Benlate. Due to the potential resistance problem with Benlate, it is suggested that the materials be mixed or alternated in a common spray schedule. Trunk injections with Aliette, Lynx, Arbotect, or Plant Vax were relatively ineffective in reducing foliar symptoms regardless of time or number of injections.

PILOT TESTS AT THE
UNIVERSITY OF TENNESSEE

Fungicide treatments, including Banner, Bravo 720, Benlate, Dithane, Systhane, and Lynx were effective in reducing dogwood anthracnose incidence in the nursery tree canopies. Pruning treatments were also effective in reducing disease incidence, but not as effective as were fungicidal treatments. Pruning plus fungicides were no more effective than fungicides alone. The use of tree injectors or soil drenches to deliver fungicide treatments did not reduce disease incidence or severity.

In other tests, tree location (shade vs. full sun), mulching, and irrigation did not influence disease severity or incidence. This may have been due to unusual dry and hot weather. Trees used in fungicidal trials in 1989 continued to be rated at a lower disease severity levels than control trees.

A PILOT TEST OF THE FUNGICIDE LYNX USED AS A
SOIL DRENCH TO CONTROL DOGWOOD ANTHRACNOSE

Flowering dogwood that are severely affected by dogwood anthracnose on the Bent Creek Experimental Forest were used to pilot test the fungicide Lynx as a soil drench for the control of dogwood anthracnose. The trees were treated by pouring a dilute mixture of the chemical in holes that had been bored in the soil around the drip line. There were no differences in the severity of the disease from May 1990 to September 1990 in the treat trees.

A PILOT TEST OF THE FUNGICIDE BANNER USED AS A
SOIL DRENCH TO CONTROL DOGWOOD ANTHRACNOSE

Flowering dogwood that are severely affected by dogwood anthracnose on the Bent Creek Experimental Forest were used to pilot test the fungicide Banner as a soil drench for the control of dogwood anthracnose. The trees were treated by pouring a dilute mixture of the chemical in holes that had been bored in the soil around the drip line. There was no difference in the severity of the disease from May 1990 to September 1990 in the treated trees.

EPICORMIC SHOOT DIEBACK OF FLOWERING DOGWOOD CAUSED BY *DISCULA* SP. DURING DORMANCY

Increased dieback of epicormic shoots was observed on flowering dogwood after the tree had gone dormant in 1987 and 1988. Further verification of this observation was made during the dormant season (October to May) in 1989. During the evaluation, 66 percent of the shoots had varying amounts of dieback; 17 percent died back to the main stem, while 17 percent remained unchanged. The evaluation showed that the increase in dieback occurred after an extreme cold period. The progression of dieback was limited by shoot internodes.

EVALUATION OF GROWTH RETARDANT FOR EPICORMIC SHOOT CONTROL ON FLOWERING DOGWOODS

Maintain A tree sprout growth retardant was used to reduce epicormic shoot formation on flowering dogwoods. The treatment caused stem and branch deformity in small trees and is not recommended for use on dogwoods.

CORRELATION BETWEEN SIMULATED ACID RAIN AND DOGWOOD ANTHRACNOSE IN THE GREENHOUSE

Bare-root, 1 year-old *Cornus florida* seedlings were planted in 1-liter pots in a mixture of 5 parts peat moss, 4 parts perlite, and 3 parts pasteurized topsoil. When leaves had emerged under controlled greenhouse conditions, the seedlings were exposed to one of four simulated rains with pH of 2.5, 3.5, 4.5, and 5.5 at the Center for Forest Environmental Studies. After 10 exposures, the seedlings were sealed in plastic bags and transported to the Resistance Screening Center, where they were inoculated with *Discula* sp., the dogwood anthracnose fungus. After 21 days the percentage of seedling leaves infected and the severity of infection were assessed. The study was done in 1989 and repeated in 1990. In both years, *Discula*-caused symptom severity increased as the simulated acid rain pH decreased from 5.5 to 2.5.

INDIVIDUAL STUDIES

DISTRIBUTION OF DOGWOOD ANTHRACNOSE IN THE SOUTHEASTERN UNITED STATES - DECEMBER 1990 [1/]

by

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ABSTRACT

Since dogwood anthracnose was found in the Southeastern United States, people from State, Federal, and private concerns have helped track its distribution. To be added to the distribution map, the diseased trees must be present in the county and have Discula sp. confirmed in the laboratory. By December 1990, 126 counties were classified in 7 Southern States as having infected trees.

INTRODUCTION

In the late 1970's a new disease (dogwood anthracnose) was found to be causing lower limb dieback and leaf lesions on flowering dogwoods (Cornus florida) in the Northeastern United States (2). In 1987 the disease caused by the fungus Discula sp. (3) was found to be affecting 30,000 acres of Cohutta Wilderness in northern Georgia (1).

Since the disease's discovery in the Southeastern United States, Federal, State, and private concerns have helped track the distribution and spread of the disease. Forest Pest Management, Region 8 has coordinated the data and prepared distribution maps for the Southeast.

METHODS

In 1987 and 1988, the States of Georgia, North Carolina, South Carolina, Tennessee, the National Park Service, and the USDA Forest Service conducted dogwood anthracnose road surveys of the mountains and foothills in their respective areas. Symptomatic dogwoods were sampled and samples were sent to

[1/] A large number of people and agencies contributed data to prepare this map. Figure 2 lists the contributors.

the Horticultural Research Laboratory at Cornell University for confirmation of the disease. A list of counties, by State, that had at least one natural growing dogwood tree, confirmed in the laboratory to be infected with the dogwood anthracnose fungus Discula sp., was started.

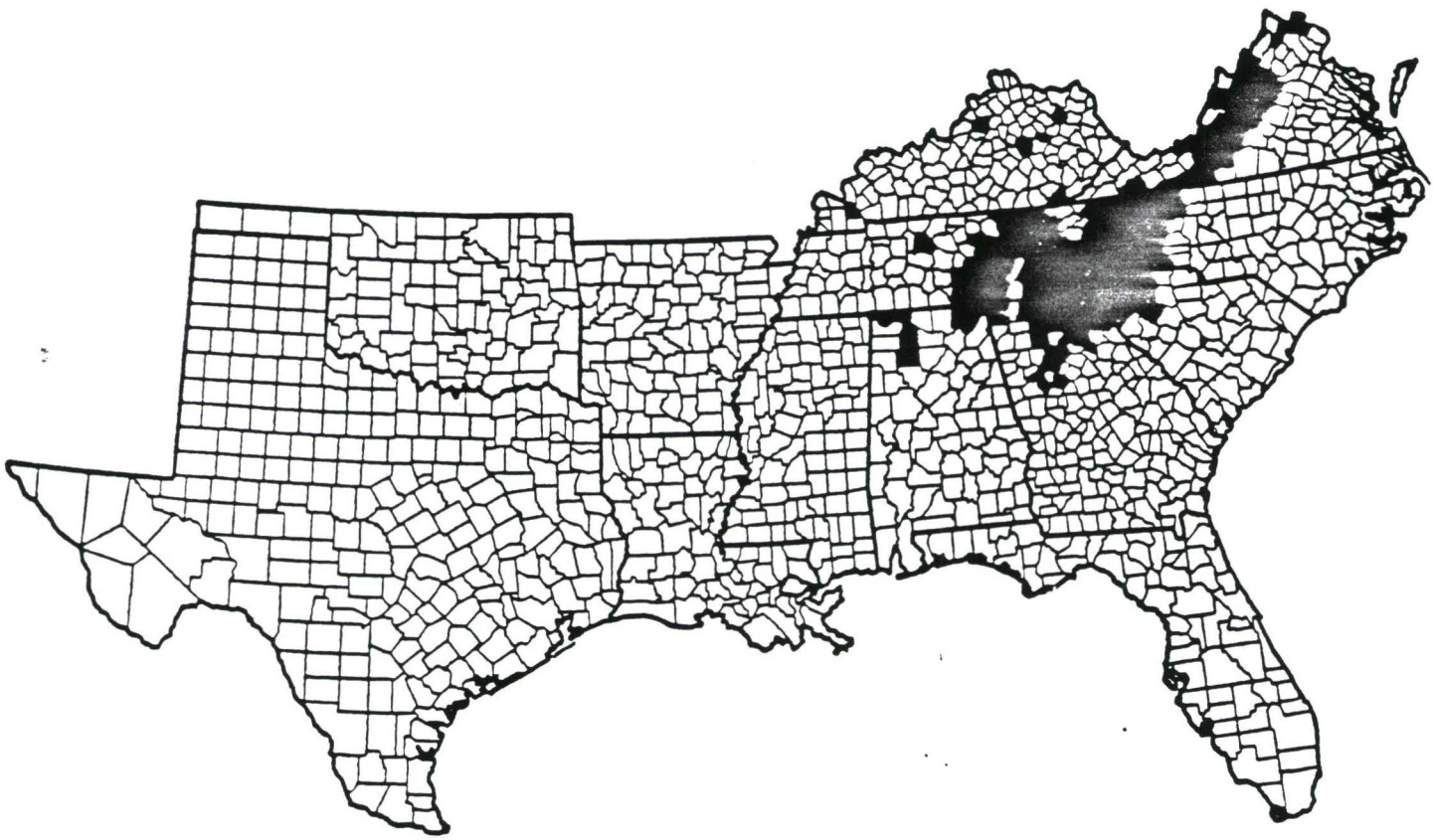
In 1989 and 1990, the survey data came from anyone who discovered an infected tree and had it confirmed in the laboratory. The person or agency reporting a specific county has been recorded from the start of the mapping activities in 1987. Counties where all of the diseased trees have been removed are not added to the map. The maps are kept up to date using a Geographic Information System, maintained by the Regional Office in Atlanta, Georgia.

RESULTS AND DISCUSSION

The list of counties in the Southeast has grown from 3 counties in 1987 to 126 in December 1990 (table 1 and fig. 1). In 1988 and 1989, the surveys and observations were detecting new areas and places where the disease had been around for some time. In 1990 the surveys and observations began to detect primarily the spread of the disease into new areas.

The disease is primarily found in the mountains, foothills, and upper Piedmont. Damage is more severe at the higher elevations and in cool moist areas in the lower elevation.

Figure 1.--Distribution of dogwood anthracnose in the Southeastern United States as of December 1990.[1/]



[1/]Map was prepared by Bob Uhler, Steve Holzman, and Charles Dull with the Geographic Information System in the Regional Office.

Table 1.--Number of counties, by year, confirmed in the laboratory to have at least one flowering dogwood tree infected with dogwood anthracnose

State	Year counties were added to the map				
	87	88	89	90	Total
Alabama	--	--	3	1	4
Georgia	1	6	11	9	27
Kentucky	--	--	1	4	5
North Carolina	--	13	5	6	24
South Carolina	--	5	1	--	6
Tennessee	--	15	14	8	37
Virginia	2	3	13	5	23
Total	3	42	48	33	126

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2. Daughtery, M.L. and C.R. Hibben. 1983. Lower Branch Dieback, a New Disease of Northeastern Dogwoods. (Abst.) Phytopathology 73:365.

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Figure 2.--List of the person or agency that first found dogwood anthracnose in a county.

STATE	COUNTY	SOURCE OF INFORMATION
NC	Allegheny	S. Spencer
		R. Baldwin
	Ashe	D. Rogers
	Avery	J. Knighten
	Buncombe	B. Anderson
		J. Knighten
	Burke	S. Dowsett
	Caldwell	D. Rogers
	Cherokee	S. Dowsett
	Clay	S. Dowsett
	Cleveland	S. Oak
	Graham	B. Anderson
		S. Dowsett
	Haywood	M. Windham
		(Smokies)
	Henderson	D. Ledford
	Jackson	B. Anderson
		J. Knighten
		D. Ledford
	Macon	B. Anderson
		J. Knighten
	Madison	S. Dowsett
	McDowell	J. Knighten
	Mitchell	J. Knighten
		S. Dowsett
	Polk	S. Spencer
	Rutherford	J. Knighten
	Swain	M. Windham
		(Smokies)
	Transylvania	B. Anderson
		J. Knighten
		D. Ledford
	Watauga	NCSU Plant Path
		Clinic
	Wilkes	D. Rogers
	Yancey	Plot Data
VA	Albermarle	J. Stipes
	Amherst	T. McCartney
	Augusta	J. Knighten
	Bath	T. McCartney
	Bedford	Blue Ridge Parkway
	Botetourt	Blue Ridge Parkway
	Carroll	Blue Ridge Parkway
	Clarke	Data From Plant Disease
	Craig	T. McCartney
	Floyd	D. Anderson
	Franklin	Blue Ridge Parkway

	Giles	T. McCartney
	Grayson	Blue Ridge Parkway
	Greene	K. Langdon
	Loudoun	Data From Plant Disease
	Montgomery	J. Stipes
	Nelson	J. Artman
	Patrick	Blue Ridge Parkway
	Roanoke	Blue Ridge Parkway
	Rockbridge	Drake
	Rockingham	D. Rogers
	Warren	S. Dowsett
	Washington	T. McCartney
SC	Anderson	A. Boone
	Greenville	A. Boone
	Laurens	Plot Data
	Oconee	A. Boone
	Pickens	A. Boone
	Spartanburg	Plot Data
AL	Jackson	B. Anderson
		J. Knighten
	Lauderdale	N. Hess
	Lawrence	N. Hess
	Winston	N. Hess
TN	Anderson	M. Windham
	Bledsoe	B. Kauffman
	Blount	M. Windham
		(Smokies)
	Campbell	B. Kauffman
	Carter	B. Kauffman
	Cocke	M. Windham
	Coffee	B. Kauffman
	Cumberland	B. Kauffman
	Davidson	B. Kauffman
	Fentress	B. Kauffman
	Franklin	B. Kauffman
	Greene	B. Kauffman
	Grundy	B. Kauffman
	Hamilton	B. Kauffman
	Hawkins	B. Kauffman
	Johnson	B. Kauffman
	Loudon	B. Kauffman
	Knox	M. Windham
	Marion	B. Kauffman
	McMinn	B. Kauffman
	Monroe	B. Kauffman
	Morgan	B. Kauffman
	Pickett	B. Kauffman
	Polk	M. Windham
		B. Kauffman
	Putnam	B. Kauffman
	Rhea	M. Windham
	Roane	B. Kauffman
	Sequatchie	B. Kauffman
	Sevier	M. Windham
		(Smokies)

	Scott	B. Kauffman
	Sullivan	S. Dowsett
	Unicoi	Plot Data
	Union	B. Kauffman
	Vanburen	B. Kauffman
	Warren	B. Kauffman
	Washington	B. Kauffman
	White	B. Kauffman
KY	Rowan	S. Dowsett
	Powell	J. Hartman
	Bell	J. Hartman
	Madison	J. Hartman
	Marshall	J. Hartman
GA	Banks	K. Bailey
	Catoosa	M. Windham
	Cherokee	K. Bailey
	Clarke	K. Bailey
	Dade	M. Windham
	Dawson	F. Hendrix
	De Kalb	K. Bailey
	Fannin	S. Dowsett
	Fayette	K. Bailey
	Franklin	F. Hendrix
	Fulton	K. Bailey
	Gilmer	S. Dowsett
	Gwinett	K. Bailey
	Habersham	Plot Data
	Hall	F. Hendrix
	Hart	F. Hendrix
	Henry	K. Bailey
	Jackson	Ed Brown
	Lumpkin	J. Knighten
	Murray	S. Dowsett
	Pickens	K. Bailey
	Rabun	B. Anderson
		J. Knighten
		S. Dowsett
	Stephens	F. Hendrix
	Towns	J. Knighten
	Union	K. Britton
	Walker	M. Windham
	White	K. Britton

Report # 91-1-25

Dogwood Anthracnose Impact Assessment in the Southeast - 1990

by

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ABSTRACT

Two hundred and ten permanent dogwood plots have been established in dogwood anthracnose affected counties in Virginia, North Carolina, South Carolina, Georgia, Kentucky, Tennessee, and Alabama. These plots were selected as a random stratified sample on a 15-mile grid. The acreage affected in the Southeast was estimated at about 1/2 million acres in 1988, 2.2 million in 1989, and increased to 5.7 million acres in 1990. Mortality increased from 0 to 3 percent from 1988 to 1990 and the percentage of severely damaged trees increased from 4 to 11 percent.

INTRODUCTION

Dogwood anthracnose (caused by Discula sp.) was found on flowering dogwoods (Cornus florida L.) in the Northeastern United States in the late 1970's (2). All sizes and ages of dogwoods were susceptible. In 1987 the disease was found in the Cohutta Wilderness in northern Georgia. The disease causes lower limb dieback and leaf lesions on flowering dogwoods.

Because the disease was new to the Southeast, and the effects were unknown, it was decided to establish a series of permanent plots (recommended by Coleman Doggett, North Carolina Forest Service) to assess the current effects and monitor the change over time.

Since the plots occurred on all ownerships, the USDA Forest Service and the States with affected counties assisted in the establishment and monitoring of the plots. Funding was provided by the USDA Forest Service, Forest Pest Management, Washington, D.C.

METHODS

Two hundred and ten plots were established by State and Federal cooperators, depending on the ownership. The plots were installed on a 15-minute-interval latitude and longitude grid. These points were plotted using a geographic information system. They were then transferred to road maps to assist in field location. The following steps were used at the map coordinate:

1. Locate nearest road to coordinate. Plot should be located within a 1-mile radius of coordinate. If no dogwood within 1-mile radius data sheet was marked NO DOGWOOD.

2. From edge of road, determine compass heading and walk toward plot at least 2 chains (132 feet).

3. Mark plot center.

4. Locate, tag, and mark (spray paint base of tree) the 10 dogwood trees (including dead) closest to plot center regardless of size and condition. Establish plot even if less than 10 trees.

5. Make all necessary measurements and complete data sheet (Figure 1). Basal area consists of overstory trees only.

6. Collect sample of leaves or twigs from each tree suspected of having dogwood anthracnose. Mark collection bag so it can be identified by individual tree. Sample should be left dry and in a cool environment. Samples should be processed as soon as possible.

Data sheets were completed for each of the plots (fig. 1). The following Mielke-Langdon dieback classes (1) were used to rate the trees:

Dieback classes
5 = Healthy
4 = 1-25% of foliage affected
3 = 26-50% of foliage affected
2 = 51-75% of foliage affected
1 = >75% of foliage affected
0 = Dead

All of the data were entered into a computer for analysis. The percentage of plots with confirmed Discula sp. was determined for each State. The acres of dogwood for each county in each State were obtained from Forest Inventory and Analysis. These county data were used to determine the total acres in affected counties, by State. The percentage of plots affected was then multiplied by the acres to estimate the acres affected, by State.

Thirty of the 1988 plots revisited in 1989 and 1990 were used to assess the change in dieback classes using the Mielke-Langdon scale.

A GIS system was used to display the approximate location of each plot for this report.

RESULTS AND DISCUSSION

Figure 2 shows the location of the permanent dogwood anthracnose plots in the Southeast. In 1988, about 14.8 percent of the permanent plots were confirmed as positive for Discula sp. By 1989 this had increased to 27.8 percent and to 50.3 percent in 1990. Using these percentages and estimates of total dogwood, the acreage affected was estimated at 1/2 million acres for 1988, 2.2 million acres for 1989, and 5.7 million acres in 1990 (table 1).

Since each tree is classified on the Mielke-London scale, 30 plots which were infected and have been remeasured three times were compared for changes over time. Table 2 shows that mortality has increased from 0 to 3 percent and severely damaged trees (Codes 2 and 1) have increased from 4 to 11 percent. The percentage of healthy trees increased in 1990. It is felt that this increase is probably caused by a very dry growing season which reduced leaf infection.

Overall, dogwood anthracnose has made major increases in area affected and severity in the Southeast. Part of this increase is finding areas that had been infected for some time, and the other part is from new areas. The disease continues to be more severe at the higher elevations and in cool wet areas close to streams. These data are being used to construct hazard maps which are not ready for use at this time.

Table 1.--Percentage and total acres affected by dogwood anthracnose in the Southeastern United States.

State	1988			1989			1990		
	Total acres	# Acres affected	(%) Acre affected	Total acres	# Acres affected	(%) Acre affected	Total acres	# Acres affected	(%) Acre affected
GA	693,132	153,875	(22.2)	1,847,076	369,415	(20.0)	2,313,671	832,922	(36.0)
NC	1,313,906	123,507	(9.4)	1,947,729	531,730	(27.3)	2,809,184	1,519,769	(54.1)
SC	899,385	158,292	(17.6)	1,005,699	295,675	(29.4)	1,005,699	737,177	(73.3)
TN	760,277	253,172	(33.3)	2,049,881	655,962	(32.0)	2,590,118	1,313,190	(50.7)
VA	90,765	13,433	(14.8)	1,246,177	346,437	(27.8)	2,619,682	1,205,054	(46.0)
Overall	3,757,465	556,105	(14.8)	8,096,562	2,250,844	(27.8)	11,338,354	5,703,192	(50.3)

Table 2.--Percentage of dogwood trees in each of six damage classes, with changes from 1988 to 1990.

Damage class 1/	1988	1989	1990
5	38%	8%	24%
4	51	66	48
3	7	17	14
2	3	4	7
1	1	4	4
0	0	1	3

1/ 5 = Healthy
4 = 1-25% of foliage affected
3 = 26-50% "
2 = 51-75% "
1 = >75% "
0 = Dead

Figure 1.--Data sheet used to record data at each of the 210 permanent dogwood anthracnose plots - 1990.

Dogwood Anthracnose Impact Survey
Data Sheet

Date _____ Latitude _____ Longitude _____

State _____ County _____ Surveyor _____

Aspect_____ Elevations _____ Basal area _____

Overstory type _____ Soil type _____

% slope _____ Landform (Ridge, Slope, Cove, Flatland) _____

Distance from plot center to farthest tree (ft) _____

Individual Tree Information

	1	2	3	4	5	6	7	8	9	10
Dieback Class										
DBH										
Tree Height										
Stem Infection Present?										
Sample?										

Misc. Information:

Instructions:

1. 10-tree plots on grid system.
2. Establish permanent plots - mark and number trees.
3. Record site and tree info.
4. Dieback classes: 0 = Dead, 1 = > 75% foliage afffected, 2 = 51%-75%, 3 = 26-50%, 4 = 1-25%, 5 = Healthy.
5. Draw plot location and stem map on back.

Figure 2.--Approximate location of the permanent dogwood anthracnose plots in the southeastern United States - 1990.

[1]Map produced by Bob Uhler, Steve Holzman, and Charles Dull in the Regional FPM office.

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A Preliminary Hazard Rating for Dogwood Anthracnose in the Southern Appalachians

by

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Resource Management and Science Division, Gatlinburg, TN

Completed through Interagency Agreement 5460-9-8016 with
USDA Forest Service, Forest Pest Management, Asheville, NC

INTRODUCTION

Background

In the mid-1970's, a new fungal disease was reported on dogwoods (Coruns spp.) in North America. First found near Chehalis, Washington, on Cornus nutalli, the disease was found in successive years northward into the Puget Sound region and into British Columbia. This disease caused lesions on leaves and defoliations, but usually not the death of the tree. About the same time, a new disease was found to be killing flowering dogwoods (Cornus florida) in the New York City area. This disease became known as dogwood anthracnose and was placed in the genus Discula. By the early 1980's, the disease was identified in Maryland and in 1987 in the Southern Appalachians (2). To date, it has not colonized the Atlantic Coastal Plain south of the Chesapeake Bay region, despite proximity to infected areas (1).

Issues

As more and more workers became attracted to the problem, a number of fundamental questions about dogwood anthracnose arose, such as: whether it is introduced to part or all of North America? how it is dispersed? what is the disease's potential range? what is the long-term effect? are there climatic parameters that limit fungus to identifiable geographic areas or habitats?

This project is concerned with the last question. Interagency monitoring of disease extent and severity has been tracked by Forest Pest Management in Asheville (1) for the entire upland South since 1987, and for the mid-Atlantic States since 1989. This has allowed the first gross mapping of the disease extent vs. fast distribution. Several investigators are currently examining the role of individual tree placement in shaded canopies or sunny exposures. Little, if any, previous work has been conducted at the "meso" scale--from several to tens of kilometers. This study will answer two specific, investigative questions:

1. Are there significant differences in anthracnose severity across a Southern Appalachian landscape?

2. If there are differences, can these be modeled accurately

enough to allow the classification of sites into a hazard rating system?

METHODS

Several study areas were selected in the Great Smoky Mountains National Park for intensive survey of dogwood anthracnose: Fighting Creek, west of park headquarters, Oconaluftee River above Cherokee, and a section of the Little River watershed near Chinquapin Knob. The Chinquapin Knob area was chosen for the conical knob-mountain, that has similar steepness and geology on all slope aspects. All three study sites were covered in 1989 or 1990 blooming season aerial photography by the USDA-Forest Pest Management. Aerial photos were used to ascertain general host distributions within the areas. Ground crews were then sent to rate dogwood stands continuously along transects selected to coincide with dogwoods, to bisect dogwood stands, and to extend into non-dogwood habitats.

Stands were mapped in approximately 50-meter or 100-meter cruise-widths, depending on size of survey party. Proceeding along a predetermined route, the dogwood resource, viewed as that portion of the stand within visual range, was classified into one of six categories and drawn by hand on topo sheets:

1. Few or no dogwoods
2. Little or no anthracnose apparent
3. Generally "light" infection (usually lower branches and seedlings) on up to 50 percent of trees
4. Moderate infection - more than half of trees with infection, but most not severely affected
5. Severe infection - most infected and more than half severely so, with loss of canopy and some mortality
6. Dying - half or more dying or already dead.

Currently, several vegetation-related Geographic Information System (GIS) themes are available for full-park coverage. There were tested for "best fit" with what was actually seen in the field. The GIS themes below were developed or customized by Charles Parker at the Uplands Field Research Laboratory. More details on each theme can be found in Parker, et al., 1990.

Theme	Resolution	How used
Vegetation type	$90m^2$	Comparison of 13 vegetation types made dogwood and anthracnose maps
Aspect (from Digital Elev. Model)	$90m^2$	Compared northerly (WNW to ENE aspects) to southerly aspects
Proximity to streams	Line data from USGS quads	Searched out 1, 2, and 3 pixels from stream segments of various orders

Topographic sheltering	$90m_2$	Topographic exposure checked against anthracnose and dogwood distribution
Moisture	$90m_2$	Two models with 9 and 13 classifications, based on topography, were used to compare

Various combinations of these themes were tested for "best fit" after it became obvious that single themes under or over predicted either geographic extent or severity. Since each theme may have multiple attributes (e.g., streams may be either first, second, or third order and may be searched out one, two, three, or more pixels), large matrices quickly developed. The largest matrix had 42 values to which low, moderate, and high were assigned, as general risk categories of anthracnose.

As each major theme combination was produced graphically, another transect was selected for ground truthing. Specific routes were selected to test the accuracy of the new GIS attributes used.

RESULTS

As expected, many theme attributes and some entire themes, such as the vegetation type, were found to be of little value, either singly or in combination. Also some themes encompassed disease extent well but had little sensitivity to severity of anthracnose.

The best results were obtained using the following GIS prescription:

Elevation: On northerly slopes, only elevations below 3,000 feet used due to lack of dogwood stands above that elevation. On southerly slopes, elevations below 3,500 feet were used. Dogwoods occur above that elevation, but stands are much more uncommon.

Stream proximity: Southerly slopes were considered to be at moderate risk only for the pixel through which stream flowed. Southerly slopes farther from streams were classified as of low risk. Northerly slopes were generally considered to be of moderate risk, unless within one pixel of first-order streams or two pixels of second-order streams.

Aspect: As used above.

Preliminary ground truthing indicated an accuracy of 60-70 percent for the first iteration. Autumn leaf fall prevented a more extensive assessment of accuracy. The map was run at two scales, 1:24,000 for the Fighting Creek area and at 1:117,000 for the entire park (contact author for a copy of the map).

DISCUSSION

Most dogwood anthracnose workers have recognized a difference in infection rates in different habitats when conducting field surveys (4). This study indicates that there is a significant difference across the landscape (in the

park) that may be attributable to temperature and moisture changes, which are, in turn, influenced by topography and distance from streams.

A preliminary accuracy assessment of 60-70 percent is good for geographic models. Although refinements may bring accuracy up, 100 percent is probably not achievable, since the model assumes there was a uniform distribution of fungus in both time and space, and this is extremely remote. The model's accuracy is also adversely affected by host density and weather in the months preceding the field survey. Since trees are known to be dying in the study areas, and new trees are being infected, repeatability of this project in the future may prove the ultimate test of accuracy.

In the meantime, this type of modeling may be useful in assessing which natural areas in forests and parks may be most at risk, and it should be tested and refined into localized models in other portions of the Southern Appalachians. Modeling the dogwood resources in each district of a land management agency will facilitate the prioritization of stands where in situ preservation efforts are not needed or may be a losing battle. It will also prioritize those stands for ex-situ preservation, through seed or scion collection. Since urbanized areas introduce a number of horticultural variables, it is not appropriate to use this rating system in other than natural areas at this time.

Further refinements in moisture modeling and the use of indicator species that are mappable through aerial photography, especially Rhododendron maximum or Tsuga canadensis may prove valuable in accurately assessing the dogwood anthracnose threat.

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Report# 91-1-21

EFFECTIVENESS OF CULTURAL TECHNIQUES TO CONTROL DOGWOOD ANTHRACNOSE

by

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ABSTRACT

Ornamental dogwood trees at the Bent Creek Experimental Forest in Asheville, North Carolina, were treated with different cultural techniques. All treated trees were pruned, mulched, and sprayed for dogwood borers. In addition, some trees received nitrogen, phosphorus, lime, or a balanced fertilizer, or were watered during dry periods. Check trees received none of the treatments. The trees were classified as being in full sun, in partial shade, or in full shade, and high vigor, moderate vigor, or low vigor. All trees were scored for disease symptoms on a score from 100 to 0, most severe to healthy, respectively. There was no correlation between the sun position and disease severity. All fertilizer and the water treatments were correlated with reduced disease development. Nitrogen fertilization had the lowest disease rating. It was also noted that watering in the afternoon increased disease symptoms and that cankers formed on the main stem if the epicormic shoots were not pruned.

INTRODUCTION

Dogwood anthracnose was found in the Northeastern United States in the late 1970's. The Northeast recommended a number of cultural control techniques for dogwood anthracnose. Since the South has a longer growing season and a variety of environmental conditions, Region 8, Forest Pest Management, began a pilot test in 1989 to evaluate these control recommendations under southern conditions.

At the Bent Creek Experimental Forest, Asheville, North Carolina, a number of ornamental dogwoods became infected in 1989. The dogwoods were treated as recommended by the North, except no fungicides were applied. There were no

prolonged dry periods in 1989, so watering was not needed. There were five trees used as check trees that received no treatment.

Overall, the treated trees appeared to be more healthy and the treatments did not stimulate or reduce dogwood anthracnose symptoms.

In 1990, the evaluation was continued and expanded to evaluate the effects of watering during dry periods or fertilization with high rates of nitrogen, phosphorus, lime, or a balanced fertilizer.

METHODS

All treated trees were pruned, mulched, and treated with Dursban for dogwood borer control. Five trees were left untreated as checks. The following treatments were applied in the spring of 1990:

1) Watering during prolonged dry periods, plus 10-20-10 fertilizer (rate:1.5#/diam. in.)
2) Fertilizing with a high nitrogen (16-0-0) fertilizer (rate:3#/diam. in.)
3) Fertilizing with a high phosphorus (0-46-0) fertilizer (rate:5#/diam. in.)
4) Fertilizing with lime only (rate:200#/1,000 ft^2)
5) Fertilizing with recommended fertilizer after soil analysis (10-20-10) (rate:1.5#/diam. in.)

Each treatment was replicated twice with three to six trees per replication. A buffer zone was left around each treatment to prevent different treatments from affecting each other. The fertilizer and lime were applied by broadcasting the material between the trunk and drip line. A soil analysis was made of each replication area before and at the end of the growing season.

The trees were rated for dogwood anthracnose in September, by finding the least affected and the most affected trees, which received scores of 0 and 100 percent, respectively. All other trees were estimated as to where they fit on the scale from 0 to 100 percent. The trees were also rated for the amount of sunlight exposure (full sun, partial shade, and full shade) and vigor (high vigor, moderate vigor, and low vigor).

RESULTS AND DISCUSSION

There was no significant difference in the symptoms on the trees in the different sun positions. There was a significant difference in symptoms on trees in different vigor classifications (fig. 1). Trees in full shade achieved only a moderate or low vigor rating. The average score on the basis of 0-100 percent was 27 for low vigor trees, 17 for medium vigor, and 8 for high vigor.

When the trees are grouped by vigor classes, the analysis of covariance showed that all treatments had less disease symptoms when compared with the checks. Nitrogen was the only treatment that had significantly less symptoms when compared with other treatments. These data show that all treatments seemed to reduce disease severity (table 1).

It was also noted that afternoon watering increased the disease and that if cankers formed on the main stem epicormic shoots were not removed.

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Figure 1.--The average score for trees affected by dogwood anthracnose on basis of 0-100 percent for tree vigor, with the most severely tree rated as 100 and the healthiest as 0.

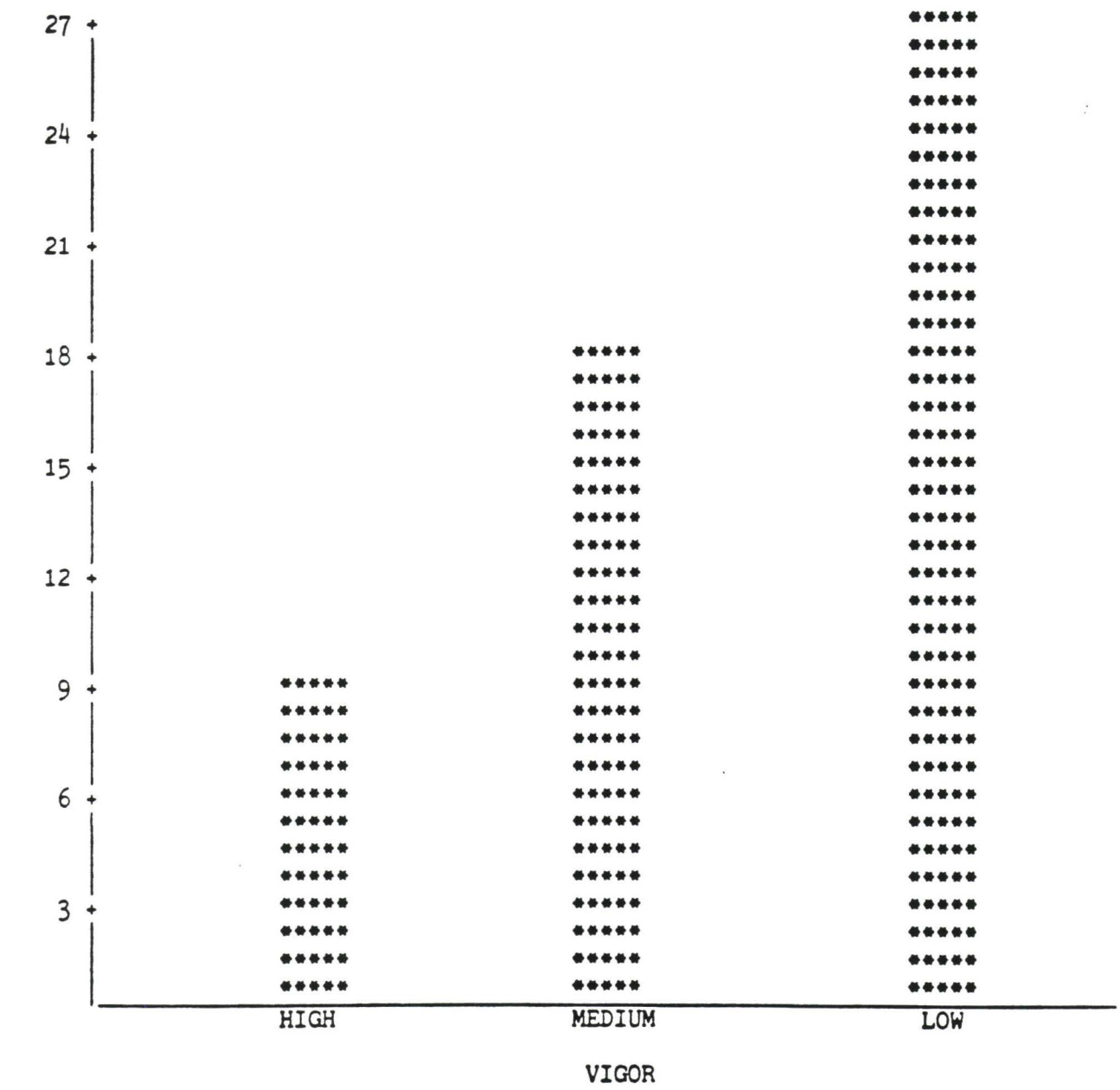

Table 1.--Severity of dogwood anthracnose on trees treated with different cultural or fertilizer treatments. The Duncan's multiple range test was run taking the affects of vigor into consideration.

Duncan	Grouping	Mean	Treat
	A	34.94	Check
B	A	27.57	Balanced
B	A	19.78	Water
B	A	14.94	Phosphorus
B	A	12.40	Lime
B		10.08	Nitrogen

Residual Effects of Control Strategies Applied in the Previous Year

by

Mark T. Windham, Alan S. Windham, and Keith R. Langdon

The use of fungicide treatments and pruning were evaluated in 1989 for disease control (1). In the 1989 experiments, pruning was ineffective in reducing dogwood anthracnose disease severity, whereas fungicide treatments were very effective. The objectives of this study were (1) to determine if symptom severity continued to be reduced in the next growing season and (2) to determine if beneficial effects of pruning had appeared the following year.

METHODS

In 1989, four dogwoods in the Great Smoky Mountains National Park (GSMNP) trees were sprayed three times (approximately 15 days apart) with either Benlate, Daconil 2787, Fore, or Zyban (1). Another six trees served as controls. Trees had been evaluated for symptom severity using the Mielke-Langdon scale (2). These trees were evaluated for dogwood anthracnose symptom severity on August 11, 1990, using the same scale.

In 1989, 23 pairs of dogwood trees had been selected in GSMNP because they were similar in d.b.h. and symptom severity and were spaced < 8m apart. One member of each pair had been pruned monthly to remove diseased tissue. In 1990, trees of each pair were evaluated using the Mielke-Langdon scale.

Data from the fungicide trail were analyzed using the ANOVA procedure of SAS and Duncan's new multiple range test. Data from the pruning experiment was evaluated using a paried T-test.

RESULTS AND DISCUSSION

Trees sprayed in 1989 with fungicides had significantly lower symptom severity scores in 1990 than did control-trees (1). Two control trees had died. Fungicide treatments from the previous year may have resulted in less initial inoculum of Discula within the tree canopies in 1990.

No significant differences were observed in symptom severity ratings in the pruning experiment. Mielke-Langdon scores averaged 3.8 for the pruning treatment and 3.9 for the controls.

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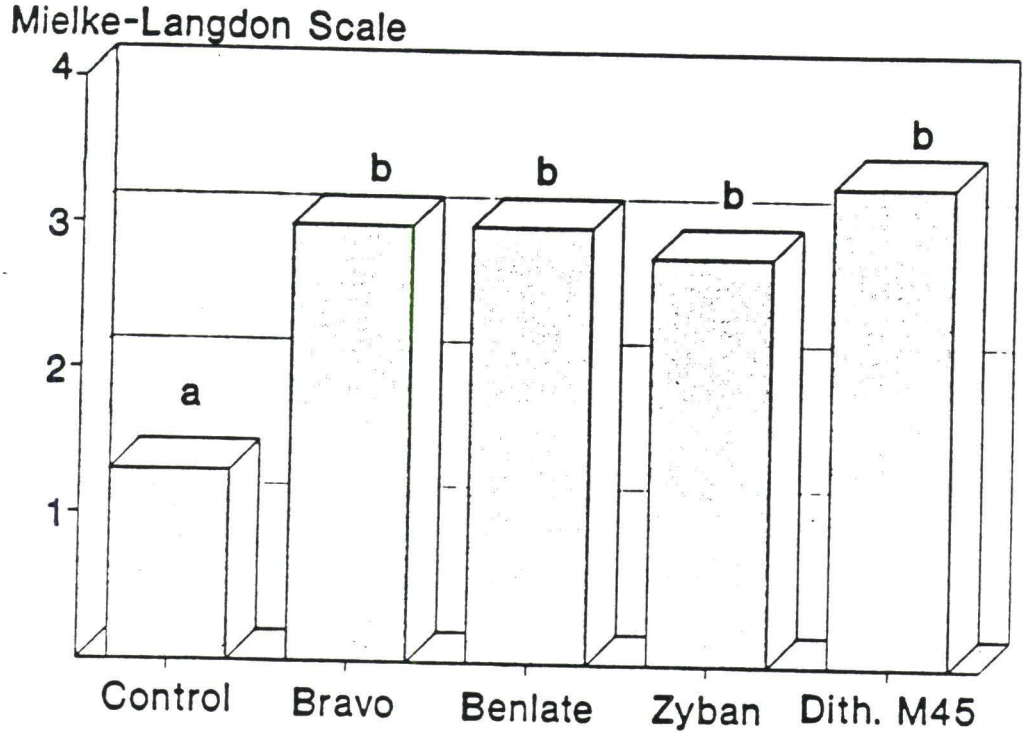
Figure 1.--Effects of fungicide sprays applied in 1989 on symptom severity in 1990.



Use of Fungicidal Sprays and Pruning to Control Dogwood Anthracnose in a Nursery Field

by

Mark T. Windham and Alan Windham

Dogwood anthracnose was detected in a commercial nursery in 1990. The nursery field consisted of 22 rows and each row was 285 m long. Disease incidence in the field was nearly 100 percent, but a gradient in disease severity ranging from severe to mild symptoms was observed. Initially, most lesions were located in the lower canopy of most trees. The field was obtained from the nurseryman for use in fungicide control trial.

Ten fungicide treatments, including an untreated control, were evaluated using a randomized complete block design with six replications. Each replication consisted of a 1 row plot (6 m long). Fungicides were used at label rates. In addition, pruning out disease tissue was also evaluated with and without fungicide treatments as a control strategy. In treatments involving pruning, trees were examined for diseased tissue and symptomatic tissue was removed. Pruning was conducted only once. Disease severity was rated using the Mielke-Langdon Scale (1) and a canopy scale (table 1).

Continued disease development was hampered by unusually dry and hot weather during June, July, and August. Differences between treatments were not detected using the Mielke-Langdon scale, but were apparent using the canopy scale method (table 2). All fungicide treatments were effective in reducing the level of disease in the canopy when compared with the controls. Pruning was effective in reducing the amount of disease in the canopy when compared with the control. However, pruning + fungicide was no more effective in disease control then fungicide treatments alone.

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Table 1.--Canopy scale values.

Score	Portion of canopy (from the base of tree) with disease
0	Canopy is healthy
1	1 - 20%
2	20 - 40%
3	40 - 60%
4	60 - 80%
5	80 - 100%

Table 2.--The effectiveness of 10 fungicidal treatments used with and without pruning for control of dogwood anthracnose.

Fungicide treatment	Pruned Yes	Pruned No	Mielke-Langdon scale	Canopy scale
ASC 66791		No	3.4 a	1.6 ab
		Yes	4.0 a	1.2 a
Banner 1.1 E		No	4.0 a	1.6 ab
		Yes	4.4 a	1.2 a
Benlate 50 DF		No	4.2 a	1.0 a
		Yes	4.4 a	1.0 a
Bravo 720		No	3.8 a	1.4 a
		Yes	3.8 a	1.4 a
Control		No	3.4 a	3.8 d
		Yes	3.8 a	2.6 c
Dithane DF		No	4.0 a	1.4 a
		Yes	4.0 a	1.2 a
Hydroclear's Ionic solution		No	4.0 a	1.8 ab
		Yes	3.8 a	2.2 bc
Lynx 2 F		No	4.0 a	1.0 a
		Yes	4.0 a	1.2 a
Systhane 2 EC		No	3.4 a	1.8 ab
		Yes	4.0 a	1.6 ab
SAN 619		No	3.8 a	1.8 ab
		Yes	4.0 a	1.6 ab

Numbers in each column followed by a letter do not differ according to Duncan's multiple range test (P = 0.05).

Dogwood Anthracnose Studies

by

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SUMMARY

Of the registered materials, Benlate and Daconil gave the best control of dogwood anthracnose leaf symptoms. While Benlate was statically better, both materials gave adequate control. Lynx, not registered for use on dogwood, was as effective as a foliar spray as Benlate. Due to the potential resistance problem with Benlate, it is suggested that the materials be mixed or alternated in a common spray schedule. Trunk injections with Aliette, Lynx, Arbotect, and Plant Vax were relatively ineffective in reducing foliar symptoms regardless of time or number of injections.

Evaluation of the effects of foliar sprays and trunk injections on the control of dogwood anthracnose

Studies were established during 1990 at Duke's Creek in the Georgia mountains. Foliar spray, trunk injection, and soil drench tests were established. Foliar sprays were applied to both leaf surfaces to runoff on a 2-or 3-week schedule beginning March 19 and ending June 27. The following fungicides were tested (formulation concentration/3.8 l water): Benlate 50DF-4.7 mL, Daconil 54%-5.7 g (2-week interval), 11.3 g (3-week interval), ASC66971-9.1 g, and Lynx-3 mL. The soil drench was applied on March 19 using 1 and 2 mL of Lynx per cm of trunk diameter in 3.8 L of water to the drip line area. Trunk injections were made on September 29, 1989; May 1, 1990; June 27, 1990; and September 24, 1990. The injection sites were placed 12 cm apart around the trunk near the root flare. Arbotect, Lynx, Plant Vax, and a combination of Arbotect and Plant Vax were injected fall and spring. Aliette was injected fall, summer, and spring. Disease assessments were made on a percentage of leaf area showing necrosis on a scale of: 0 = no symptoms, 1 = trace to 5 percent, 2 = 6-25 percent, 3 = 26-50 percent, 4 = 51-75 percent, 5 = 76-100 percent, 6 = leaf abscised. Twenty-five leaf pairs in the lower crown of each tree were related on May 29, June 19, and July 20. In the trunk injection test, it was necessary to prune limbs from the lower crown for rating due to size of the trees. Each treatment was replicated four times. Data were analyzed using ANOVA and means separated using Duncan's multiple range test.

Disease incidence and intensity were severe until July 1, when it became dry. The results of the spray test are presented in table 1. In general, Benlate and Lynx gave the best control. On the final data, ASC66971 suppressed leaf symptoms almost as well. While Daconil was the least effective on the 2-week schedule, it was effective enough to give good control.

Although Benlate had a statistical advantage in control, it has the disadvantage of giving rise to resistant stains of fungi when used alone. Control can probably be best realized using a mixture of Benlate and Daconil, or alternating the use of the two materials.

None of the injected materials at Duke's Creek gave adequate control of dogwood anthracnose, whereas at the Georgia Mountain Experiment Station no symptoms were evident due to inadequate rainfall and warm temperatures. While it appeared that the spring injection of Lynx controlled the disease, it should be noted that the fall/spring treatment which was made at the same time in the spring was ineffective. Thus, trunk injection with these compounds appears to be erratic at best.

Effect of soil fertilization on dogwood anthracnose

A field study was started to supplement the pot study on fertilization effects reported in 1989. Five tree plots were established at the Georgia Mountain Experiment Station in Blairsville. Fertilization treatments involving NH_4NO_3, $CaHPO_4$, and $Ca(OH)_2$ were applied on April 13. Treatment levels were either high or medium for each nutrient according to the UGA Soil and Plant Testing Laboratory standards for dogwoods. All possible combinations were tested, giving nine treatments. The test was replicated four times. Overhead irrigation was installed to maintain moisture for growth and for inoculations. Two inoculations were made on August 22 and September 17. Due to relatively warm temperatures, symptom development was insufficient to evaluate the test. The test will be inoculated in the spring of 1991, and results will be included in the 1991 report.

Table 1.--Dogwood anthracnose fungicide spray test - 1990

Treatment	rate (per gallon)	5-29-90	6-19-90	7-20-90
			Every 2 weeks	
Benlate	4.7 mL	0.07500 E	0.07000 E	0.05000 D
Daconil	5.7 g	0.21667 D	0.17262 D	0.36628 B
Daconil	11.3 g	1.36000 A	1.27000 A	1.22000 A
ASC66971	9.1 g	0.34000 C	0.29500 C	0.19500 C
Lynx	3 mL	0.02500 E	0.10500 DE	0.08500 D
Control		0.57000 B	0.51500 B	0.22500 C

Table 2.--Dogwood anthracnose soil drench test

Treatment rate		5-29-90	6-19-90	7-20-90
Lynx	2mL/cm stem	1.64500 A	1.66500 A	1.60900 A
Lynx	1mL/cm stem	1.68000 A	1.60000 A	1.45000 B
Control		0.57000 B	0.51500 B	0.22500 C

Table 3.--Dogwood anthracnose fall trunk injection test

Treatment	5-29-90	6-19-90	7-20-90
Arbotect	1.56500 A	2.22500 A	1.77000 B
HWG 1608 (Lynx)	1.32500 B	1.89500 B	1.71500 B
Plant Vax	1.56000 A	1.66500 B	1.86000 B
Combo Plant Vax & Arbotect	1.32500 B	2.30000 A	2.24000 A
Control	1.45500 AB	1.62000 B	1.56000 B

Table 4.--Dogwood anthracnose fall/spring trunk injection test

Treatment	5-29-90	6-19-90	7-20-90
Arbotect	1.20000 C	1.48670 D	1.56670 C
HWG 1608 (Lynx)	1.75000 B	2.98500 A	2.57000 A
Plant Vax	1.55000 B	1.76500 BC	1.57500 C
Combo Plant Vax & Arbotect	2.00000 A	1.97500 B	2.22000 B
Control	1.60500 B	1.58000 CD	1.62000 C

Table 5.--Dogwood anthracnose spring trunk injection test

Treatment	5-29-90	6-19-90	7-20-90
Arbotect	1.20000 C	1.73000 A	1.38500 BC
HWG 1608 (Lynx)	0.61000 C	1.00500 C	1.16000 C
Plant Vax	1.03000 A	1.42000 B	1.64000 B
Combo Plant Vax & Arbotect	1.17500 A	1.65500 AB	1.35000 BC
Control	0.82500 B	1.58500 AB	2.48500 A

Table 6.--Dogwood anthrancose spring spring/summer fall trunk injection

Treatment	5-29-90	6-19-90	7-20-90
Aliette	1.36000 A	1.75500 A	1.33500 B
Aliette	1.29000 A	1.00000 B	0.77500 C
Aliette	1.01000 B	1.13500 B	1.38000 B
Control	0.82500 B	1.58500 AB	2.48500 A

Chemical and Cultural Control of Dogwood Anthracnose At Lookout Mountain National Park

by

Mark T. Windham, Alan S. Windham, and Keith R. Langdon

Dogwood anthracnose epidemics had been severe on Lookout Mountain in 1989 (2) in both urban and forest areas. Pilot tests including both chemcial and cultural control methods were utilized in 1990 to determine if anthracnose symptom severity could be reduced. The objectives of this study were: to determine the effects of amount of sunlight or shade on symptom development, (2) to determine if mulching and irrigation would reduce symptom severity, and (3) to evaluate the effectiveness of fungicides applied as drenches, injections, and foliar sprays.

Methods

Sun vs. shade. Twenty-nine plots in urban areas of Lookout Mountain and Signal Mountain were established in 1990. Each plot consisted of 10 trees that were at least 1 m tall. The type of sunlight that each tree was subjected to was determined using the scale listed in table 1. Landscapes were also classified as very open (few shrubs, no trees other than dogwoods), open (few trees other than dogwoods), woody (most dogwoods under canopies of other trees, and very woody (dogwoods under dense tree canopies and many shrubs and bushes). The Mielke-Langdon (ML) (1) scale was used to evaluate symptom severity.

Irrigation and mulching. Twenty trees at "The Commons," a Lookout Mountain city park, were used in a study to evaluate the effects of irrigation and mulch on anthracnose disease incidence. Ten trees were mulched with hardwood bark mulch and irrigated daily with pop up nozzles that directed water at the base of the trees. The other 10 served as controls. Symptom severity was rated using the ML scale.

Injectors. Twenty-four trees, average d.b.h. = 9.7 cm, were used in a trial evaluating Mauget injectors. Trees were injected at recommended rates with Mauget injectable fertilizer, Fungisol, Fungisol + fertilizer, Fungisol PV, or Fungisol PV + fertilizer. Each treatment was replicated four times and four times served as controls. Trees were rated for symptom severity before the study began using the ML scale and again on August and October.

Fungicide sprays and drenches. Another fungicide trail was conducted on potted dogwood trees that were set underneath the canopies of diseased dogwoods. Banner and Lynx were used in two treatments each as a root drench and a foliar spray. The fungicides Bravo 720, Dithane DF, Zyban, and Benlate were applied as foliar sprays. Ionic solutions (made by Hydroclear Inc.) were applied as foliar sprays and also evaluated. Trees were sprayed throughout the summer on a 2-week spray schedule. Each treatment was replicated eight times served as controls.

Results and Discussion

Sun vs. shade. Disease severity was not significantly correlated with the amount of sunlight or shade that trees experienced during the day. These data disagree with observations made in 1989 and this disagreement may have been due to unfavorable environmental conditions (hot and dry) for disease development that experienced throughout the summer. No differences in symptom severity were noted in open vs. woody environments.

Irrigation and mulching. No significant differences in symptom severity were observed between trees irrigated and mulched and trees that served as controls. Although symptoms were moderately severe in late spring, symptoms did not continue to progress in any treatment as the summer progressed.

Injectors and fungicide sprays and drenches. Foliar anthracnose symptoms were very severe at the beginning of the study (table 2). As the season progressed, few additional lesions developed on new foliage and symptom severity ratings decreased. No signficant differences were noted between treatments in either study (tables 3 and 4).

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Table 1.--Rating scale for type of light dogwoods experienced in urban settings.

Type of sunlight	Score
Direct sun	6
Mostly sun	5
Partial sun	4
Direct shade	3
Mostly shade	2
Total shade	1

Table 2.--Symptom severity data with and without Mauget fungicide and fertilizer treatments.

Treatment	Initial rating	Symptom severity rating	
		August 1	September 10
Control	1.8	2.3	2.9
Control + fertilizer	1.8	2.4	2.7
Fungisol	1.3	2.2	3.1
Fungisol + fertilizer	2.1	2.5	2.9
Fungisol PV	1.3	2.4	3.0
Fungisol PV + fertilizer	1.5	2.6	3.1

Table 3.--Data for fungicide treatments on potted dogwoods.

Fungicide treatment	Symptom severity rating		
	August 1	August 15	September 12
Banner - Drench	5.0	4.2	3.8
Banner - Spray	5.0	4.5	4.4
Lynx - Drench	5.0	4.3	4.0
Lynx - Spray	5.0	4.8	4.8
Bravo 720	5.0	4.3	4.0
Dithane-M45	5.0	4.2	4.3
Zyban	5.0	4.4	4.5
Control	4.8	3.9	3.8
Ionic solutions - Cu	5.0	3.9	4.1
- Cu + I	5.0	4.2	4.0
- Ag	4.9	3.8	3.9
- Ag + I	5.0	4.5	4.2

A Pilot Test of the Fungicide Lynx Used as a Soil Drench to Control Dogwood Anthracnose

by

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ABSTRACT

Flowering dogwood (Cornus florida L.) that were severely affected by dogwood anthracnose (caused by Discula sp.) on the Bent Creek Experimental Forest were used to pilot test the fungicide Lynx as a soil drench for the control of dogwood anthracnose. The trees were treated by pouring a dilute mixture of the chemical in holes that had been bored in the soil around the drip line. There were no differences in the severity of the disease from May 1990 to September 1990 in the treated trees. There were also no differences in the severity of the disease in the control trees. Lynx applied as a soil drench did not reduce dogwood anthracnose symptoms in this pilot test.

INTRODUCTION

Dogwood anthracnose (caused by Discula sp.) was found on flowering dogwoods (Cornus florida L.) in the Northeastern United States in the late 1970's (3). All sizes and ages of dogwoods were susceptible. In 1987 the disease was found in the Cohutta Wilderness in northern Georgia and now has been found in 117 counties in 7 Southeastern States (1). It is primarily found in the mountains and foothills.

Lynx has been successfully used as a spray to control dogwood anthracnose. This pilot test was done to see if Lynx would control dogwood anthracnose on flowering dogwood when used as a soil drench.

METHODS

A location in the forest, where flowering dogwoods (Cornus florida L.) were known to be severely infected with dogwood anthracnose (caused by Discula sp.) on the Bent Creek Experimental Forest, was chosen as the site for a soil drench pilot test using the fungicide Lynx. There were 5 blocks of 10 trees each. Each block had six treated trees and four control trees.

Ten holes one and 1 1/2 inch diameter and 3 inches deep were drilled in the soil around the drip line of each tree. Lynx was applied at 8 grams of active ingredients per centimeter of tree diameter. The calculated amount of fungicide was diluted in 1/2 gallon of water for each treated tree.

Equal volumes of the dilution were poured into each hole around the treated trees. One-half gallon of water was poured equally into the holes around the control trees.

The pilot test was installed in mid-April at the time of dogwood flowering. Evaluations (using the Mielke-Langdon damage classes) (2) were recorded once a month beginning in June and ending in September.

RESULTS AND DISCUSSION

We wanted high disease pressure on the fungicide, so the area chosen was severely infected with dogwood anthracnose. There were 30 treated and 20 control trees in the evaluation. Those trees treated with the fungicide Lynx as a soil drench showed no evidence of reduced disease symptoms (table 1). The difference in disease severity between June and September was 0.36 for the treated trees and 0.10 for the control trees (table 1).

Table 1.--Average severity of dogwood anthracnose infection on the Lynx plots using the Mielke-Langdon damage classes.[1/]

Plot number	June reading		September reading	
	Treated trees	Control trees	Treated trees	Control trees
1	1.80	1.50	2.33	1.75
2	2.83	2.25	3.17	2.75
3	1.67	2.25	2.33	2.25
4	1.50	2.25	1.83	1.75
5	2.50	2.00	2.50	1.75
Average	2.07	2.05	2.43	2.05

[1/] 5 - Healthy
4 - 1-25% of foliage affected
3 - 26-50% of foliage affected
2 - 51-75% of foliage affected
1 - > -75% of foliage affected
0 - Dead

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ACKNOWLEDGMENT

Thanks to Mobay Corporation for supplying the fungicide used in this pilot test.

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Report #91-1-18

A Pilot Test of the Fungicide Banner Used as a Soil Drench to Control Dogwood Anthracnose

by

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ABSTRACT

Flowering dogwoods (Cornus florida L.) that are severely affected by dogwood anthracnose (caused by Discula sp.) on the Bent Creek Experimental Forest were used to pilot test the fungicide Banner as a soil drench for the control of dogwood anthracnose. The trees were treated by pouring a dilute mixture of the chemical in holes that had been bored in the soil around the drip line. There were no differences in the severity of the disease from May 1990 to September 1990 in the treated trees. There were also no differences in the severity of the disease in the control trees. Banner applied as a soil drench did not reduce dogwood anthracnose symptoms in this pilot test.

INTRODUCTION

Dogwood anthracnose (caused by Discula sp.) was found on flowering dogwoods (Cornus florida L.) in the Northeastern United States in the late 1970's (3). All sizes and ages of dogwoods were susceptible. In 1987 the disease was found in the Cohutta Wilderness in northern Georgia and now has been found in 117 counties in 7 Southeastern States (1). It is primarily found in the mountains and foothills.

Banner has been successfully used as a soil drench in the control of anthracnose on pecan Carya illinoensis (Wangenh.) K. Koch. The pilot test was done to see if Banner would control dogwood anthracnose on the flowering dogwood.

METHODS

A location in the forest, where flowering dogwoods (Cornus florida L.) were known to be severely infected with dogwood anthracnose (caused by Discula sp.) on the Bent Creek Experimental Forest, was chosen as the site for a soil drench pilot test using the fungicide Banner. There were 5 blocks of 10 trees each. Each block had six treated trees and four control trees.

Ten holes 1 1/2 inch diameter and 3 inches deep were drilled in the soil around the drip line of each tree. Banner was applied at 15 grams of active ingredients per tree. The calculated amount of fungicide was diluted in 1/2 gallon of water for each treated tree.

Equal volumes of the dilution were poured into each hole around the treated trees. One-half gallon of water was poured equally into the holes around the control trees.

The pilot test was installed in mid-April at the time of dogwood flowering. Evaluations (using the Mielke-Langdon damage classes) (2) were recorded once a month beginning in June and ending in September.

RESULTS AND DISCUSSION

We wanted high disease pressure on the fungicide, so the area chosen was severely infected with dogwood anthracnose. There were 30 treated and 20 control trees in the evaluation. Those trees treated with the fungicide Banner as a soil drench showed no evidence of reduced disease symptoms (table 1). The difference in disease severity between June and September was 0.07 for the treated trees and 0.10 for the control trees (table 1).

Table 1.--Average severity of dogwood anthracnose infection on the Banner plots using the Mielke-Langdon damage classes.[1/]

Plot number	June reading		September reading	
	Treated trees	Control trees	Treated trees	Control trees
1	3.00	2.75	3.00	3.00
2	2.67	2.75	2.67	3.00
3	3.00	3.25	3.17	3.00
4	3.00	3.25	3.00	2.75
5	2.83	3.50	3.00	3.25
Average	2.90	3.10	2.97	3.00

[1/] 5 - Healthy
4 - 1-25% of foliage affected
3 - 26-50% of foliage affected
2 - 51-75% of foliage affected
1 - > -75% of foliage affected
0 - Dead

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ACKNOWLEDGMENT

Thanks to CIBA-GEIGY Corporation for supplying the fungicide used in this pilot test.

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Report #91-1-03

EVALUATION OF A GROWTH RETARDANT FOR EPICORMIC SHOOT CONTROL ON FLOWERING DOGWOODS

by

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Ken Knox
John Knighten

ABSTRACT

Maintain A tree sprout growth retardant was used to reduce epicormic shoots on dogwood. The treatment caused stem and branch deformity in smaller trees and is not recommended for operational use.

INTRODUCTION

Dogwoods have a tendency to produce epicormic shoots on the main stem of the tree. These are more common on trees under stress. It has been noted that dogwood anthracnose causes an increase in the number of these shoots. The tender young shoots are highly susceptible to Discula sp., which causes dogwood anthracnose. The fungus can quickly move down these shoots and cause main stem cankers. One of the control recommendations is to prune these shoots off the tree to keep the cankers from developing. This appears to work well but multiple shoots can develop after pruning. Maintain A is a chemical shown to reduce epicormic shoots in other species of trees. This product was tested on trees infected by Discula sp.

METHODS

Twenty Discula sp. infected dogwoods with epicormic shoots that ranged in size from 5 inches to 1 inch were selected for treatment. The shoots were pruned off flush with the stem and Maintain A, which contains Chlorofluernol was sprayed on the pruned area in accordance with the label. The trees were treated in May and readings were made in September 1990.

RESULTS AND DISCUSSION

On trees larger than 2 inches in diameter, the number of new sprouts was almost eliminated and we did not see an adverse effect to the tree. The number of sprouts on trees smaller than 2 inches was reduced, but the chemical was translocated and caused leaf and stem deformity. Also, small branches on large trees were sprayed and resulted in the same problem. Because of this adverse effect, we do not recommend the use of this product to control epicormic sprouts on dogwoods.

EPICORMIC SHOOT DIEBACK OF FLOWERING DOGWOOD CAUSED BY *DISCULA* SP. DURING DORMANCY

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ABSTRACT

Increased dieback of epicormic shoots was observed on flowering dogwood (*Cornus florida*) after the tree had gone dormant in 1987 and 1988. Further verification of this observation was made during the dormant season (October to May) in 1989. During the evaluation, 66 percent of the shoots had varying amounts of dieback, 17 percent died back to the main stem while 17 percent remained unchanged. The evaluation showed that the increase in dieback occurred after an extremely cold period. The progression of dieback was limited by shoot internodes.

Correlation Between Simulated Acid Rain and Dogwood Anthracnose in the Greenhouse

by

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Bare-root, 1-year-old Cornus florida seedlings were planted in 1 liter pots in a mixture of 5 parts peat moss, 4 parts perlite, and 3 parts pasturized top soil. When leaves had emerged under controlled greenhouse conditions, the seedlings were exposed to one of four simulated acid rains of 2.5, 3.5, 4.5, and 5.5 at the Center for Forest Environmental Studies. After 10 exposures the seedlings were sealed in plastic bags and transported to the Resistance Screening Center where they were inoculated with Discula sp., the dogwood anthracnose fungus. After 21 days the seedlings were read by assessing the percentage of leaves infected and the severity of the affected leaves. The study was done in 1989 and repeated in 1990. The results for 1989 and 1990 showed that severity of Discula sp. caused symptoms increased as the simulated acid rain pH decreased from 5.5 to 2.5 (See following chart).

Percent of leaves affected

Rain pH	1990	1989
2.5	32 a	54 a
3.5	21 a b	23 b
4.5	17 b c	26 b
5.5	9 c	.4 c

Severity of injury

Rain pH	1990	1989
2.5	71 a	78 a
3.5	59 a b	49 b
4.5	46 b	42 b
5.5	26 c	1 c

United States
Department of
Agriculture

Forest Service
Southern Region

Protection Report R8 - PR 18

Results of the 1989 Dogwood Anthracnose Pilot Test in the Southeastern United States

RESULTS OF THE 1989 DOGWOOD ANTHRACNOSE PILOT TEST IN THE SOUTHEASTERN UNITED STATES

USDA Forest Service
Southern Region

RESULTS OF THE 1989 DOGWOOD ANTHRACNOSE PILOT TEST IN THE SOUTHEASTERN UNITED STATES

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CAUTION: Use pesticides selectively and carefully. Follow recommended practices for the disposal or surplus pesticides and pesticide containers. Some States have restrictions on the use of certain pesticides. Check your local and State regulations. Also, because registrations of pesticides are under constant review by the Environmental Protection Agency, consult your State forestry agency, county agent, or State extension agent to be sure the intended use is still registered.

SUMMARY

Dogwood anthracnose, caused by Discula sp., was discovered in the South in 1987. Because of the importance of the resource and the seriousness of the disease, the Washington Office of the Forest Service provided $80,000 in pilot test funds to evaluate northeast recommendations under southern growing conditions in 1989. The USDA Forest Service, National Park Service, University of Georgia and the University of Tennessee combined forces to evaluate: 1) fungicides; 2) fertilization; 3) pruning; 4) leaf wounding; 5) Koch's postulates; 6) cultural practices such as mulching and dogwood borer control and 7) simulated acid rain effects under a variety of southern growing conditions.

Most of the fungicides tested reduced symptom expression. Benlate, Bravo (Daconil), Fore, Zyban and Dithane all gave some degree of control. The effectiveness varied at different sites, but in general Benlate and Daconil gave the best results. A new, nonregistered fungicide, Lynx, gave almost complete control. Fungicide trunk injections did not have much effect on disease severity. Phosphorus fertilization stimulated leaf symptom severity, liming reduced leaf severity and, in one potted-plant test, nitrogen stimulated shoot mortality. All of the pruning tests indicate that pruning was of little value. The leaf wounding test demonstrated that wounding has little effect on the infection process and damage to leaf tissues should not increase disease severity. Koch's postulates were completed using a preinoculation acid mist treatment. Cultural practices such as mulching, fertilizing, pruning and dogwood borer treatment increased the tree vigor on large, established trees, but had little effect on disease severity. Tests demonstrated that there is a correlation between simulated acid rain and disease severity under laboratory conditions. We also demonstrated that spring aerial photography could be used to assess import.

Note: The 1989 data were very encouraging. A great deal has been learned, but additional testing and evaluation are needed. Issues such as timing of fungicide applications, rates and types of fertilizers, pruning groups of trees and epicormic shoots, acid rain correlation and cultural practices all need to receive additional testing. The Washington Office of the Forest Service has provided $70,000 in 1990 to pursue these issues.

BACKGROUND

Dogwood anthracnose was first reported by Pirone in 1978. The diseases caused a widespread rapid deterioration of flowering dogwood in New York and Connecticut. Pirone attributed the symptoms and mortality to Colletotrichum gloeosporiodes We believe that the disease he found is the same one that is now reported to be caused by a species of Discula. In 1983, Daughtrey and Hibben reported a lower branch dieback disease with the same symptoms on flowering dogwood in New York, Connecticut, New Jersey and Pennsylvania. They observed trees in Planting Fields Arboretum, Oyster Bay, Long Island and a woodland site at the Brooklyn Botanic Garden Research Center at Ossining, N.Y. They reported the cause of the disease to be a species of Discula. About this

time, Margery Daughtrey wrote a Cornell University bulletin on the disease describing the symptoms and control techniques. Her bulletin notes that the disease was more severe on dogwood in a forest setting. Hibben and Daughtrey reported the reason for a sudden onset of anthracnose over part of the northeastern range and its coincidental outbreak on western flowering dogwood was unknown. They speculated that climatic changes may be a factor and that the disease may be introduced. They also felt that droughts or sudden climatic changes may have predisposed the trees to infection. In 1984, a survey of dogwood anthracnose was made in Catoctin Mountain National Park. Mielke and Langdon found that only 3 percent of the dogwoods were disease-free, and that about one-third were dead. Schneeberger and Jackson repeated the survey in 1988 and found that 89 percent of the dogwoods were dead, there was almost no regeneration, and all remaining trees were diseased. Byther and Davidson described a similar disease on western flowering dogwoods in western Washington and named it Dogwood Anthracnose. In 1983, Salogga and Ammirati reported the disease on western flowering dogwood in Oregon, Idaho, and British Columbia. They reported the causal organism to be Discula. Daughtrey and Hibben compared the symptoms, signs and organisms on the western flowering dogwood and the eastern flowering dogwood. They concluded that the same disease occurs in both areas. It was at this time that the disease on eastern flowering dogwood was named dogwood anthracnose. This changed the common name from lower branch dieback. In 1985, Mielke and Daughtrey wrote a pest alert designed to help assess the distribution and spread through reporting by people who read the alert. By 1987, the disease had been reported in over 60 counties in nine Northeastern states (Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Virginia, and West Virginia).

Since the late 1970's, there was considerable speculation as to whether dogwood anthracnose could move into the southeastern United States. Articles had been written in major newspapers in the South to alert the public, but it was felt that the cool-loving fungus might be confined to the northern part of the dogwood range. In October 1987, Anderson and Hoffard from the USDA Forest Service office in Asheville, N.C. were contacted about an unusual number of dogwoods dying on the Cohutta Ranger District on the Chattahoochee National Forest in northern Georgia. All of the symptoms matched those of dogwood anthracnose that had been reported in the northeastern United States. Foresters estimated the affected area to cover about 30,000 acres of the Cohutta Wilderness. Because this may have been the only affected area in the South, samples were sent directly to Cornell University to prevent local movement of the fungus to noninfected areas. The samples were identified as positive for Discula, the causal organism of dogwood anthracnose. The National Forest and State Forester of Georgia were notified of the occurrence. Soon thereafter, Bob Zahner from Clemson University reported an unusual problem with dogwoods in Cashiers, N.C. This area was checked and also found to be positive for Discula. The affected area was much larger than the 30,000 acres found in Georgia. At this time the State Forester of North Carolina was notified and a meeting of State and Federal personnel from the affected and adjacent States were invited to a meeting in Dillard, GA in February, 1988. This group became a dogwood anthracnose working group and agreed that the top priority was to assess the disease distribution. The Southern Region of the Forest Service distributed a southern version of the dogwood anthracnose pest alert.

Daughtrey, from Cornell University, had agreed to process samples from anyone needing help. By the second working group meeting in May 1988, the disease had been found in Georgia, North Carolina, South Carolina, Tennessee, and Virginia. The disease was reported to affect trees of all sizes, and was more common in the mountains and cool, wet valleys. Six nurseries in North Carolina and one in South Carolina were reported to have diseased trees. Fungicide trials were started in Georgia and Tennessee and a joint pilot test proposal was prepared for submission to our Washington Office. Coleman Doggett, North Carolina Pest Control Forester, proposed that permanent plots be established on a 15 mile grid to assess the current and future impacts. These plots were installed by State and Federal personnel in each of the respective States. In June 1988, the fungus had been found in so many locations that the Forest Service and the University of Georgia initiated screening services. About September, the working group developed a news release, but it was decided not to send the release until more information was collected. After this point the information became common knowledge by word of mouth to the press and public. As a result, the news release was never made. The National Park Service did distribute a news release on the disease in the Smoky Mountains National Park. About this time the awareness of the dogwood anthracnose and its impact was receiving major newspaper and other media coverage.

A third meeting of the dogwood anthracnose working group was held in October 1988. By this time, it was clear that the techniques developed and recommended in the Northeast needed to be pilot tested in the South. A joint proposal between the State and Federal working group members was developed for import assessment and pilot testing. The pilot test part of the proposal was funded at $80,000 . These funds were distributed between the University of Georgia, University of Tennessee, National Park Service and USDA Forest Service, Forest Pest Management, Southern Region.

The Northeastern United States was recommending:

Control

Dogwoods receiving good cultural care will be better able to withstand anthracnose during years in which the disease is favored by weather conditions. Maintain the health of dogwoods by watering during periods of drought. Mulching trees can help to reduce watering needs as well as protect trunks from mechanical injury. Avoid overhead watering to minimize the chance for leaf infections. Improve air circulation around trees to help dry foliage and reduce infection.

Effective control is possible only if the disease is detected before extensive dieback occurs. Prune and dispose of diseased twigs and branches to reduce potential sources of inoculum and improve tree appearance. Raking up fallen leaves may be of some benefit. Remove succulent branches as they form to prevent trunk canker formation. Avoid high nitrogen fertilizers, which stimulate succulent branching. Trees with poor vigor may be bolstered by applying a balanced fertilizer in early spring.

Chemical

Fungicides should be used only to supplement a cultural control program. Applications of chlorothalonil, mancozeb or benomyl will protect against leaf infections. Apply 3 or 4 sprays during leaf expansion in the spring, at 10 - 14 day intervals. If conditions are favorable for disease development later in the growing season, additional fungicide applications may be beneficial.

The southeastern pilot test was designed to evaluate these recommendations under Southern growing conditions. The activities by each agency were as follows:

1. University of Georgia
    a) Fungicide foliage and trunk injection (large trees).
    b) Starch analysis (large trees).
    c) Fertilizer effects (potted trees).

2. University of Tennessee
    a) Fungicide trials (potted trees).
    b) Pruning test (large trees).

3. Great Smoky Mountains National Park
    a) Fungicide trials (large trees).
    b) Pruning test (large trees).

4. USDA Forest Service, Forest Pest Management, Southern Region
    a) Pruning test (large trees).
    b) Fertilizer trials (potted trees).
    c) Fungicide test (potted trees).
    d) Leaf wounding test (potted trees).
    e) Simulated acid rain test (potted trees).
    f) Aerial photography (large trees).
    g) Cultural practices test (large trees).

Beyond the Northeast recommendations, the starch 9 test was used as a possible survey tool. The leaf wounding and simulated acid rain were completed as a followup to Koch's postulates. The aerial photography was tested because the technique works on other diseases and would be a valuable survey tool. Additional fungicides were added because they showed promise on like diseases and could be used on dogwoods if they worked. Lynx was tested because it was a new class of chemical that was effective on like diseases for other tree species.

The appendix contains the detailed reports for each of the pilot tests. A brief summary of the findings for each pilot test follows:

University of Georgia - by R.W. Roncadori and F.F. Hendrix

The University of Georgia's part of the pilot test consisted of three parts. In part one, they evaluated the effects of fungicide foliar sprays and

trunk injections. They tested Bravo, Benlate, Rubigon, Arbotect and Lynx for foliage sprays and Arbotect, CGA and Fungisol for injection. All foliage applied fungicides gave some degree of control. Lynx was the best, followed by Benlate and Arbotect. Trunk injection did not provide very good control. Phase two was the effect of severity on root starch. In this test, they found that even with severe infection the starch reserves were not reduced. The final part was the effect of fertilization on infection. Their test showed that phosphorus increase symptoms, lime reduced symptoms and nitrogen had no effect.

University of Tennessee - Mark Windham

The University of Tennessee pilot test had two parts. In part one they evaluated the fungicides Bravo, Zyban, Benlate, and Dithane. All fungicides gave some degree of control, but the results varied with the site. It was reported that Zyban and Benlate may delay tree maturity in the fall. In part two, individual trees were pruned of all dead and diseased material throughout the growing season. This practice did not reduce disease severity. It was proposed that a block pruning may be more beneficial.

Great Smoky Mountains National Park - by Janet Rock, Keith Langdon and Mark Windham

The Great Smoky Mountains National Park part of the pilot test was to pilot test four fungicides and evaluate the effectiveness of pruning. For the fungicides, Benlate and Fore gave about a 60-percent reduction in foliar symptom while Zyban and Daconil reduced severity by 46 and 32 percent, respectively. Pruning did not provide any benefit. However, block pruning may be of benefit.

USDA Forest Service, Forest Pest Management, Region-8 - by Robert L. Anderson, Paul C. Berrang, John L. Knighten, Salley E. Dowsett, Carol H. Young, K. Ann Lawton, Walter R. Salazar and Carolyn A. Scott

The USDA Forest Service part of the 1989 pilot test consisted of severn parts:

Test 1 was a pruning study of mature trees. The dead and dying wood was pruned from all trees once a month. The disease was not reduced by pruning but we did note that pruning of the epicormic shoots may prevent the fungus from entering the main stem. This will be evaluated in the 1990 pilot test.

Test 2 involved using different fertilizers on potted seedlings. Phosphorus increased leaf symptom while nitrogen increased shoot mortality. These data show clear relationship between nutrient levels and this disease.

Test 3 was also a potted seedling study where Daconil was used on a 7-and 14-day spray schedule. The 7-and 14-day treatment significantly reduced infection over the controls and all fertilizer treatments (Fertilizer Fungicide

Test). In the wounding and fungicide test, Daconil reduced the percent of leaves affected by 70 percent.

Test 4 was a wounding test where the leaves were wounded with carborundum and then inoculated with spores of Discula sp. In potting media with a pH of 4.5 there was no significant increase in infection. For the potting media 5.5 pH there was a significant increase in infection but significantly less than the acid mist pretreatment.

Test 5 involved treating the seedlings with different concentrations of simulated acid rain prior to inoculation with Discula sp. The percentage of leaves infected and the severity of symptom development was increased as the rain pH was decreased. However, symptom development was decreased as the soil pH was increased. This test is being repeated in 1990 and a field phase is being added.

Test 6 was the evaluation of aerial photography as a survey tool. Photographs were taken in the spring at peek flower production using color infrared and natural color film. Natural color at 1/5000 scale was judged as the best. The Great Smoky Mountains National Park reported that there was better resolution with light cloud cover. This is a valuable tool for assessing change over large areas.

The final pilot test phase was a cultural practice test installed at the Bent Creek Experimental Forest. A number of large dogwoods were mulched, pruned, fertilized, and had dogwood borer control. These trees were treated late in the growing season but showed a major visible improvement over the check trees in vigor. No apparent change in disease severity results. These trees will be evaluated in 1990.

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APPENDIX

DOGWOOD ANTHRACNOSE STUDIES
UNIVERSITY OF GEORGIA

R. W. Roncadori
F. F. Hendrix

FINAL REPORT

Dogwood Anthracnose Studies
University of Georgia

R. W. Roncadori
F. F. Hendrix

A. Evaluation of the effects of foliar sprays and trunk injections on the control of dogwood anthracnose.

Studies were established during 1989 at two sites in the Georgia mountains. A foliar spray test and two trunk injection tests were conducted in the Duke's Creek Falls area, whereas, a single trunk injection test was carried out at the Georgia Mountain Experiment Station at Blairsville. Foliar sprays were applied to upper and lower leaf surfaces to run off on a two-week schedule beginning 22 March and ending 22 August. One treatment consisted of an application of Bravo on a monthly basis. The following fungicides were tested (formulation concentration/3.8L of water): Bravo 54% - 4.7 ml, Bravo (monthly) - 23.5 ml, Benlate 50DF - 4.7 ml, Rubigan 12.5EC - 2.3 ml, Arbotect 20-S - 4.7 ml, and HWG 1608 22.5DF - 3 ml. Tree trunks were injected using the Mauget micro-injectors on 10 August 1988 at both locations and on 19 April 1989 at Duke's Creek Falls. The injection sites were placed 12 cm apart around the tree circumference near the root flare. The following fungicides were tested: Arbotect 20-S (2.4/injector), CGA 453 (0.6 ml/injector), and Fungisol (4 ml/injector). Disease assessments were made on a % leaf area showing necrosis on a scale of: 0 = no symptoms, 1 = trace to 5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 75-100%, and 6 = leaf abscised. Twenty five leaf pairs were tagged per tree in the lower crown and observed throughout the foliar spray study along with other leaf pairs

arising on the same branch axis. In the trunk injection test it was necessary, because of tree size, to prune several samples from the crown each time a disease rating was made.

Disease incidence and severity were intense during the growing season with loss ratings increasing steadily from May to August at Duke's Creek Falls (Table 1). Significant disease control was evident with all fungicide treatments throughout the test period. Best results occurred with HWG 1608 followed by Benlate and Arbotect. Both Bravo applications were effective to a lesser degree and Rubigan provided significant but marginal control.

Trunk injection was less effective in controlling dogwood anthracnose than were foliar sprays (Table 1). Trees injected in August 1988 showed some degree of disease control, whereas there was no evidence of control in trees injected during April 1989. Best results were obtained with Fungisal and Fungisol PV was marginally effective. At the Georgia Mountain Station site, disease pressure was inadequate to allow evaluation of the trunk injected fungicides.

B. Effect of disease severity on root starch content.

To determine whether foliar symptoms would suppress photosynthesis sufficiently to be reflected in root starch storage, trees with varying degrees of disease control were selected from the foliar fungicide test on December 16, 1989. Three root samples/tree were collected from three trees with 26-50% of the leaf surface area affected as well as from three trees with less than 5% of leaf surface area necrotic. The samples were processed using the I_2KI visual estimate method (Wargo, P.M. 1975. Estimating starch content in roots of deciduous trees - a visual technique. USDA Forest Service Research Paper NE-313 9 p.). With the sugar maple standard as a

comparison, all dogwood samples had starch levels in the high category range of 12-25% starch. The percent starch is specific for sugar maple and may not reflect the actual starch concentration in dogwood since we did conduct a quantitative chemical assay for the compound.

C. Effect of soil fertilization on dogwood anthracnose.

A pot study was carried out to determine the effect of soil fertilization on dogwood anthracnose. A sandy loam soil with the following chemical properties was used: pH-52, P-22, K-26, Ca-530, mg 37, and NO_3 32 ppm. High and low levels of N, P, and Ca were established using $NH_4(NO_3)_2$ (Table 2). Trees were planted individually in pots on April 6 and maintained in the greenhouse until June 29, then set out at Duke's Creek. Disease readings were taken on July 19 after which no additional foliar symptoms occurred.

Orthogonal analysis of main effects indicated that symptoms were more pronounced when P fertilization was increased and suppressed when Ca fertilization was higher. N fertilization had little effect, possibly since our high and low rates were not widely different.

TABLE 1. Dogwood Anthracnose Fungicide Tests -1989

Fungicide	Foliar Sprays Sampling dates 5-10-89	6-14-89	7-19-89	8-10-89	9-7-89
BRAVO	0.500 BC*	0.970 C	0.994 D	1.093 D	1.058 D
BRAVO (M)	0.559 B	1.309 B	1.461 C	1.378 C	1.691 C
BENLATE	0.339 D	0.647 D	0.325 F	0.572 F	0.784 E
RUBIGAN	0.530 B	1.278 B	1.625 B	1.819 B	1.949 B
ARBOTECT	0.375 CD	0.585 D	0.659 E	0.617 E	0.698 E
HWG 1608	0.325 D	0.273 E	0.320 F	0.354 G	0.461 F
CONTROL	0.890 A	1.867 A	2.655 A	3.080 A	2.999 A
		INJECTED TREES-1989			
CONTROL	1.345 A	1.978 BC	2.483 B	2.925 B	2.828 B
FUNGISOL PV	1.125 B	2.043 B	2.538 B	2.573 C	2.655 B
ARBOTECT	1.475 A	1.753 C	2.170 C	3.189 B	3.002 B
FUNGISOL	1.434 A	2.419 A	3.365 A	3.860 A	3.721 A
		INJECTED TREES-1988		5-18-89	9-7-89
FUNGISOL				1.553 B	1.233 C
CONTROL				1.835 A	1.875 A
ARBOTECT				1.060 C	1.785 A
CGA				0.780 D	1.690 AB
FUNGISOL PV				1.887 A	1.565 B

*Significant differences according to Duncan's Multiple Range Test p = 0.05.

TABLE 2. Effect of soil fertilization on dogwood anthracnose.

Treatment #	Nutrient level (ppm)*			Disease Rating
	N	P	Ca	
1.	H 86	H 113	H 803	1.39
2.	H 142	H 106	L 603	1.91
3.	H 116	L 25	H 839	0.97
4.	H 150	L 15	L 442	0.86
5.	L 120	H 107	H 747	1.28
6.	L 77	H 98	L 586	1.46
7.	L 105	L 20	H 931	0.84
8.	L 100	L 15	L 476	1.24

* = Nutrient concentration after mixing
H = High level
L = Low level

CONTROL OF DOGWOOD ANTHRACNOSE AT THREE LOCATIONS IN EASTERN TENNESSEE

Mark T. Windham

Dogwood anthracnose, caused by a Discula sp., was first identified in the Southeastern United States by Dr. Bob Anderson, U.S. Forest Service (USFS). Since the first report, the disease has been found in seven southeastern states. In 1989, the USFS funded research concerning control of dogwood anthracnose. This report concerns the research that was contracted between the USFS and the University of Tennessee. The objectives for this research were:

1. To evaluate fungicide treatments that had been effective in the Northeastern U.S.
2. To determine if pruning enhanced the effectiveness of chemical control measures.

Materials and Methods

Three Tennessee locations were selected for this study: Chilhowee Mountain, Ozone, and Roaring ForK Creek in Great Smoky Mountain National Park. Plot locations were selected based on elevation, proximity to water, and level of dogwood anthracnose occurring naturally in the native dogwood population (Table 1).

Fungicide treatments and rates included were: control (no fungicide treatment), Benlate 50 WP at .16 oz/gal, Bravo 75 at .18 oz/gal, Dithane M45 at .24 oz/gal, Lynx at 2 ml/gal, and Zyban at .24 oz/gal. Lynx was used only at Ozone. One drop of a spreader-sticker (Triton B-1956) was added to each gallon of spray for most treatments. No spreader sticker was added to Bravo 75 treatments. Trees were sprayed on a 10 day-spray schedule that ended August 21 at Roaring Fork and on August 27 for the other two locations. Initial fungicide application were made before the trees were transported to the test plots.

Each fungicide treatment was sprayed to run off on 20 potted dogwood trees at each location. Dogwood trees were approximately 2 ft high. At each location, 10 naturally propagated dogwood trees were selected to serve as sources of inoculum. These trees were rated for disease severity using the Mielke-Langdon scale (Table 1). The potted trees were placed in a randomized block design with 10 replications. Trees underneath one "source" tree served as one block. Within each block, one tree of each fungicide treatment was selected at random and pruned to remove any leaves with symptoms of dogwood anthracnose prior to fungicide applications.

Disease severity was estimated for each fungicide-pruning combination using Mielke-Langdon and Horsfall-Barratt scales. Data were recorded each time the trees were sprayed. Data was analyzed using the Proc GLM procedure of SAS. Duncan's Multiple Range Test was used to separate treatment means when appropriate.

Results and Discussion

Disease severity ratings for trees that had been pruned were not different from ratings for trees that had not been pruned. Because the plots were located underneath heavily diseased trees, the trees in the test plots may have been so overwhelmed with inoculum that pruning was not effective.

Fungicide treatments were effective in reducing disease severity at all locations (Fig. 1-3). Since data were similar for both disease rating scales, data are only reported using Mielke-Langdon scale. No differences were observed at any location before July 5. Disease severity levels were usually to low or inconsistent in the control trees during the first 2 to 4 weeks after the trees were set out for differences between treatments to be significant.

Some fungicides were more effective at one location than at other locations. For example, Bravo treatments were much more effective at Chilhowee Mtn. (Oct. 16-Fig. 1) than they were at Ozone (October 17-Fig. 3). Although rainfall amounts were not recorded at the test plots, we consistently observed that the potting mix at Ozone was much wetter than at Chilhowee Mtn. Since the canopys over both plots were similar, we attributed this phenomenon to greater rainfall at Ozone than at Chilhowee Mtn. Since the spreader-sticker was not added to the Bravo sprays, the fungicide may have washed off the trees more quickly at Ozone than at Chilhowee Mtn. Similar results were also observed with the Dithane-M45 treatments. In past experiments on other crops, we have had problems maintaining protection with Dithane M45 even with the incorporation of a spreader-sticker when rainfall was heavy.

At Ozone, the Lynx treated trees often looked better than trees treated with other fungicides although these differences were not always significant (Fig. 3). Comparisons between Lynx and the other fungicides at Ozone may not be valid. The Lynx treated trees were set out at Ozone 20 days after the other fungicide treatments had begun (Table 1). The effects of this delay on disease infection and severity were unknown.

Although fungicide applications were stopped in late August, disease severity ratings in October were lower for trees that had been treated with fungicides than for trees used as controls. Most leaves of the control trees were dead and were hanging on the trees. Leaves of trees used in the Lynx, Bravo, and Dithane M45 treatments had turned red and were falling off the trees. The leaves in the Benlate and Zyban treatments were green. Terminal buds of the Zyban and Benlate treated trees were still green and soft. Buds on trees treated with other fungicides or used as controls, had "harden-off". Since dormancy in the Zyban and Benlate treated trees was delayed, trees were left at the three locations to ascertain if the Zyban and Benlate treated trees were more susceptible to cold injury. Similar delays in

foliage maturity have been observed in soybeans that had been treated with benlate. The trees will be returned to the greenhouse before March 1 and allowed to break dormancy in the greenhouse. Leaves will be examined for symptoms of dogwood anthracnose and trees will be rated for bud necrosis due to cold injury.

Conclusions

1. Fungicide treatments were effective in reducing disease severity of dogwood anthracnose.

2. Pruning was not a effective way of reducing disease severity in this experiment.

3. Fungicide applications may have residual effects on disease severity several weeks after the last fungicide application.

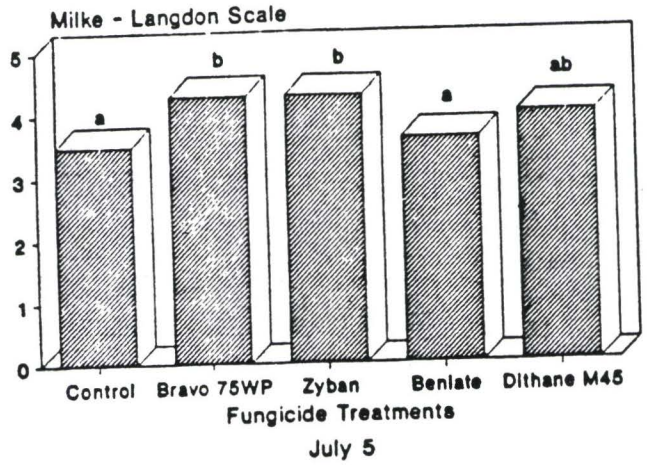
4. Zyban and Benlate may delay tree maturity in the fall and delay formation of leaf abscission layers.

Table 1. Environmental characteristics of locations used in this study and dates experiments were initiated at each location.

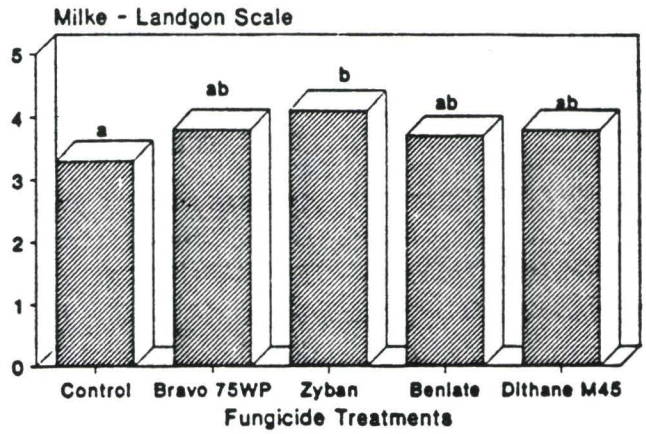
Location	Elevation (ft)	Proximity to water	Disease Severity[1]	Date Started[2]
Chilhowee Mtn.	2,250	>1500 ft	2.8	June 14
Ozone	1,443	425 ft[3]	2.2	May 31
Roaring Fork	1,985	12 ft	2.0	June 9

[1]Disease severity = average Mielke-Langdon score for the 10 trees that served as sources of inoculum.
[2]Date experiment started at each location. Lynx treatment started on June 19.
[3]Horizonal distance from plot to creek. Creek was in a gorge approximately 90 feet below plot.

1. Effects of fungicide treatments on dogwood anthracnose disease severity at Chilhowee Mountain, TN.



July 5



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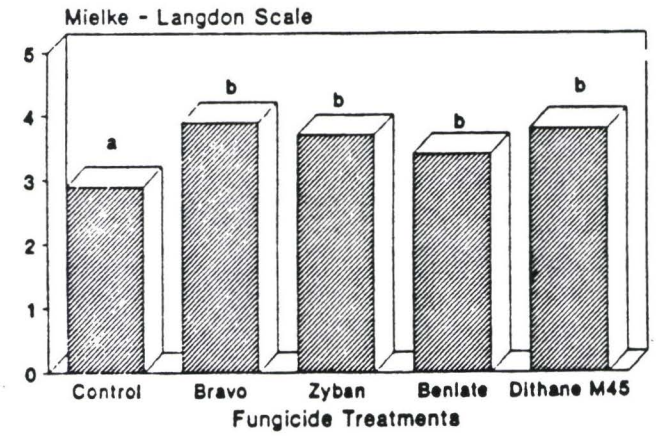
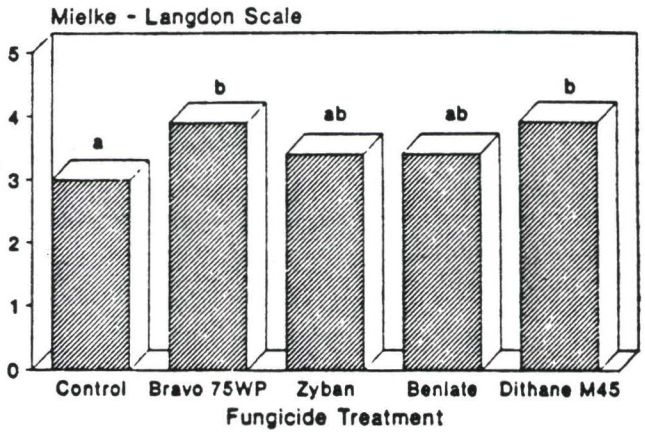


August 16



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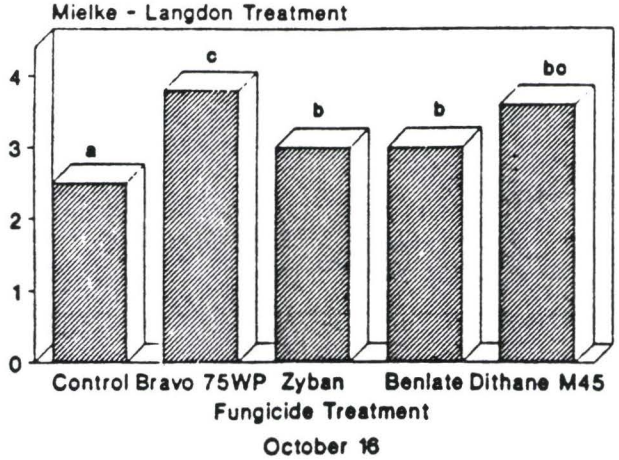
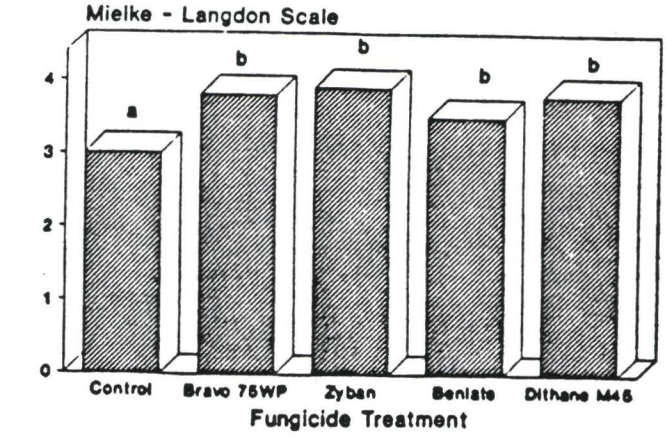


October 16



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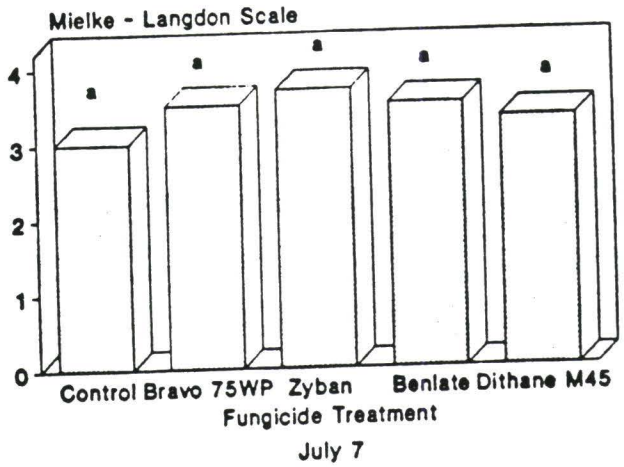
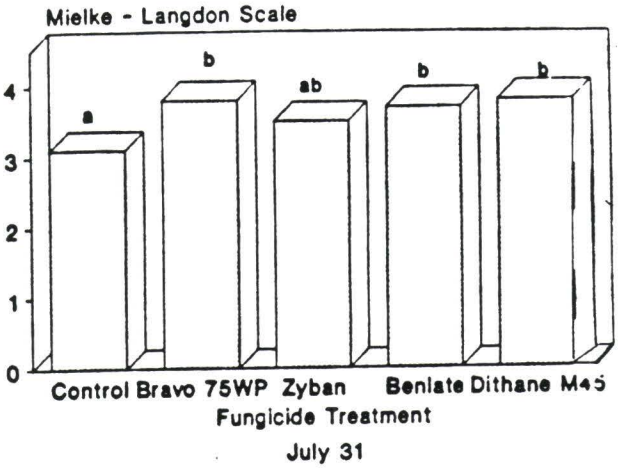
2. Effects of fungicide treatments on dogwood anthracnose disease severity at Great Smoky Mountain National Park



July 7



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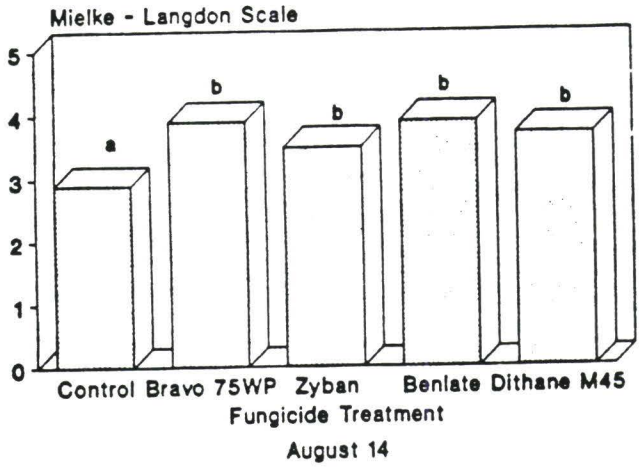

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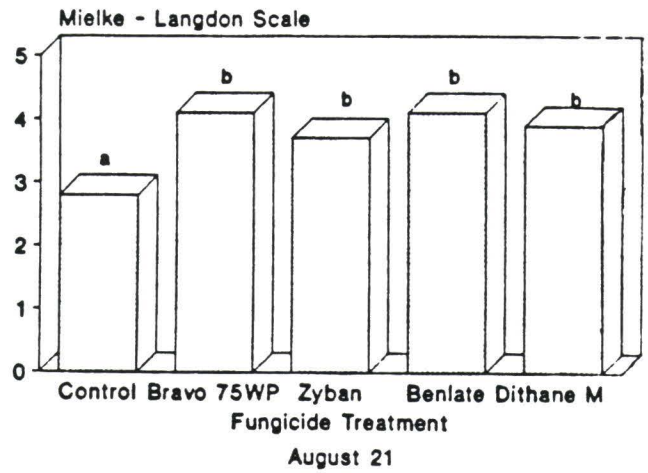

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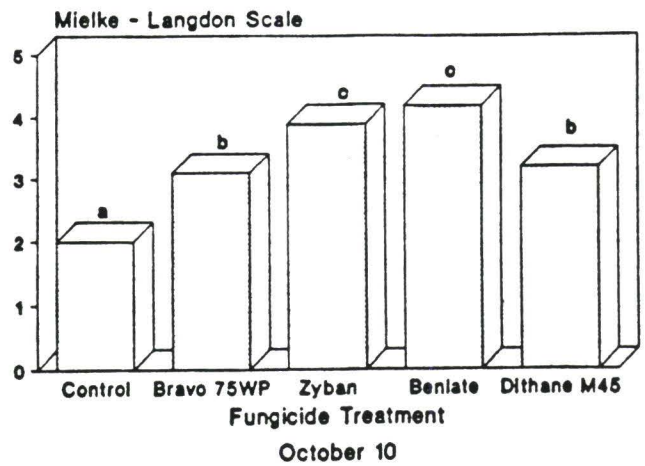
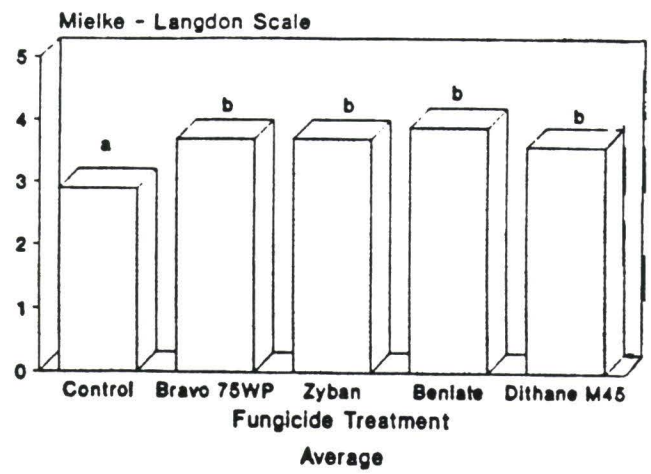


October 10



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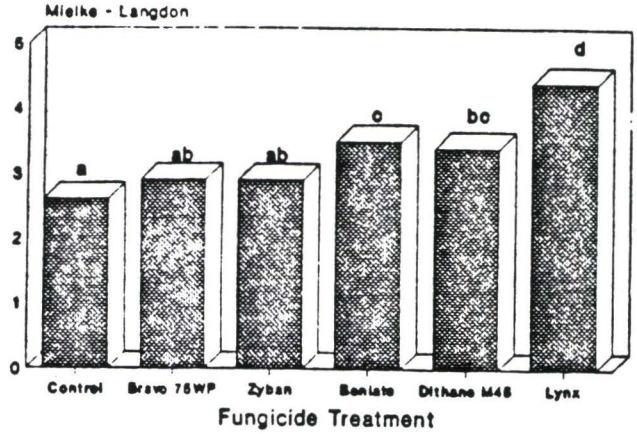
3. Effects of fungicide treatments on dogwood anthracnose disease severity at Ozone, TN.



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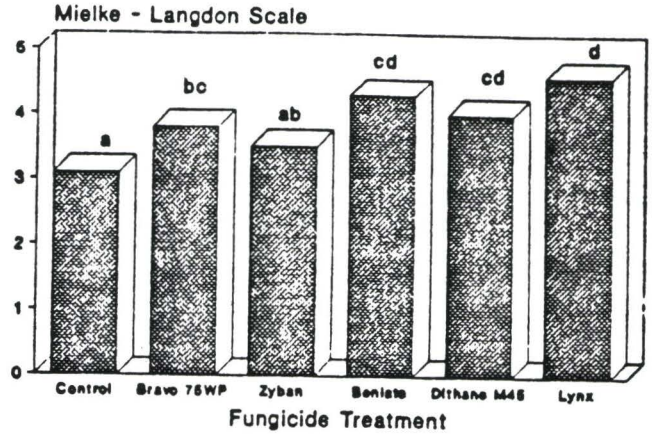

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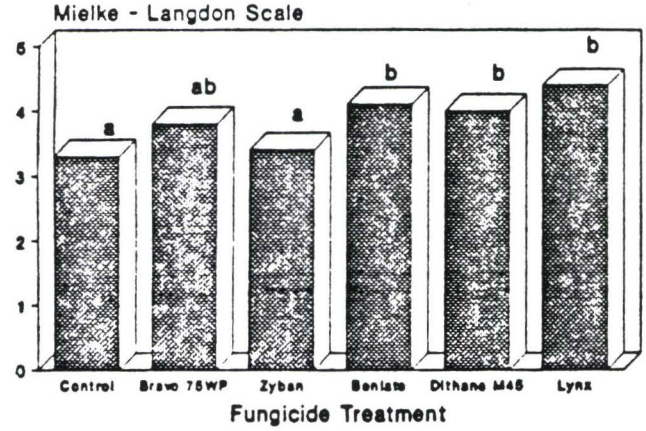

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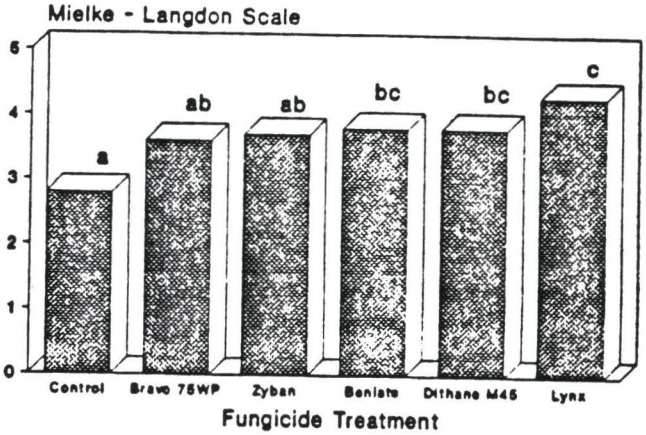

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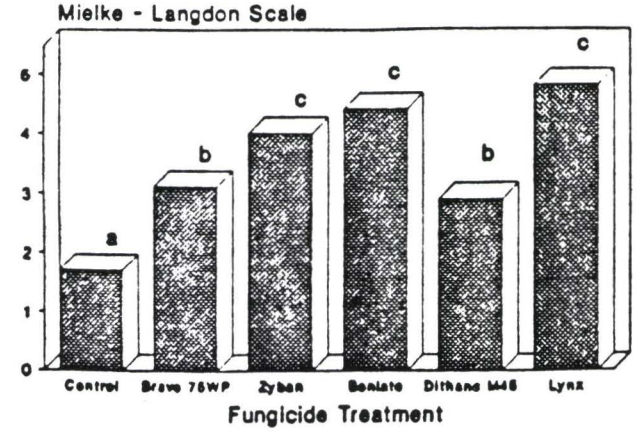

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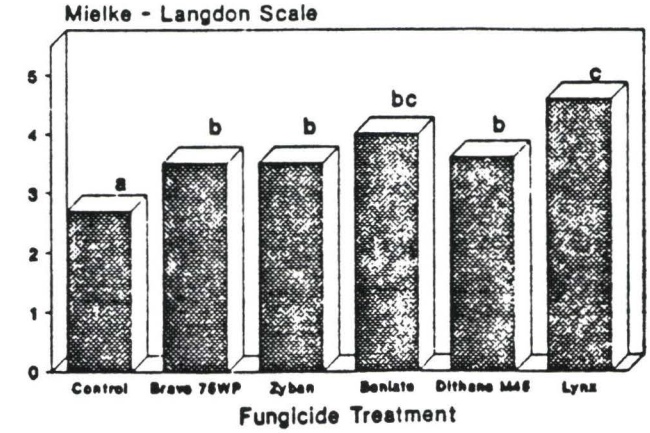

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FUNGICIDAL AND PRUNING CONTROLS FOR DOGWOOD ANTHRACNOSE GREAT SMOKY MOUNTAINS NATIONAL PARK

Janet Rock
Keith R. Langdon
Dr. Mark Windham

Fungicidal and Pruning Controls for Dogwood Anthracnose

Great Smoky Mountains National Park

Janet Rock
Great Smoky Mountains National Park

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Department of Entomology
and Plant Pathology
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December, 1989

BACKGROUND

In June 1989, the U.S. Forest Service (USFS), Southern Region, and the National Park Service (NPS), Great Smoky Mountains National Park (GRSM), entered into an Interagency Agreement (Agreement Number CA-5460-0-8016, GRSM) to field test a segment of a pilot program for control of dogwood anthracnose. Other aspects of the pilot control program were being carried out simultaneously by several other agencies and universities in the southern Appalachians.

As stated in the agreement, Great Smoky Mountains National Park was to undertake the following two project objectives: (1) assess the efficacy of four fungicidal agents on mature trees in a natural forest setting, and (2) assess the efficacy of pruning of trunk sprouts in a natural forest setting as a means of preventing tree mortality. The two sub-projects were completed in different locations of the park and are reported below separately - Part I (Fungicides) and Part II (Pruning).

INTRODUCTION

Cornus florida is a common native, deciduous understory tree found in many hardwood and conifer forest types throughout the eastern states. It is a highly valued food source for wildlife; many species of birds depend on its fruit during fall migration, and white-tailed deer and other herbivorous mammals eat the foliage, twigs and bark in addition to the fruit (Mitchell et al., 1988). The flowering dogwood has one of the highest foliage contents of calcium, from 2 to 3.5 percent (Hepting, 1971), and is, therefore, an important soil builder as well.

The flowering dogwood is also a prized ornamental, used in lawns and parks throughout the east. It reaches its densest populations in the southeastern states. Many southeastern cities, such as Knoxville, Tennessee, and Atlanta, Georgia, have large economically important festivals focused on the dogwood blooming season. Flowering dogwood adds significantly to visitor enjoyment of the region's national and state parks and forests.

Dogwood anthracnose, a disease of the flowering dogwood (Cornus florida), was first reported in Connecticut and New York in 1978 and 1979 by Pirone. He observed a rapid deterioration of C. florida and attributed the decline to infection by Colletotrichum gloeosporioides. In 1983, Daughtrey et al. reported a lower branch dieback disease having the same symptoms in New York, Connecticut, New Jersey and Pennsylvania but found a fungus (placed in the genus Discula) consistently associated with the diseased trees (Daughtrey et al., 1988). Byther and Davidson described a similar disease of the western flowering dogwood (C. nuttalli) in Washington State in 1979 and named it dogwood anthracnose. In 1983, Discula sp. was again found to be associated with diseased dogwood trees in Oregon, Idaho and British Columbia. Daughtrey et al. (1988) agreed with Byther and Davidson that

Discula sp. was the causal agent in both geographic locations. Since the earliest eastern infections in New York, Connecticut, Massachusetts and New Jersey, dogwood anthracnose has appeared on C. florida in parts of Delaware, Maryland, West Virginia, Virginia, North Carolina, South Carolina, Alabama, Georgia, Kentucky and Tennessee (Daughtrey et al., 1988).

PART I - Fungicidal Control

Control of the disease is particularly difficult in natural stands. These trees are probably more susceptible to infection because forest conditions of decreased temperature and wind and increased humidity are favorable to the spread of the fungus. Daughtrey et al. (1988) investigated the chemical control of the dogwood anthracnose fungus in New York state in 1985 and 1986. Their data showed that Daconil 2787 and Manzate 200, applied to the foliage of C. florida at approximately ten-day intervals during leaf expansion, provided the best protection out of five fungicides tested (Daughtrey et al., 1988).

The primary objective of our study was to test the effectiveness of four fungicides (Zyban, Benlate, Daconil 2787, and Fore) for the control of Discula sp. in a naturally seeded stand of C. florida. Although Daughtrey et al.'s study (1988) implied a reduction in foliar symptoms in response to fungicide treatment, this is the only research reported to date on the control of the anthracnose fungus with chemicals in a natural setting. In addition, no research of this type has been conducted in the southeastern United States where the climate and soils may differ considerably from that of the northeast.

Materials and Methods

Field research was conducted on a naturally seeded stand of Cornus florida from May through September 1989 in the Great Smoky Mountains National Park, Sevier County, Tennessee.

The study site was located on Ash Hopper Branch, a small drainage in a primarily second-growth mixed deciduous community, at approximately 1,600 feet elevation. This site was selected because; (1) the anthracnose fungus had been present on C. florida individuals in the Ash Hopper drainage since the summer of 1988, (2) the study trees were accessible by truck (which was necessary for the foliar applications), and (3) the area was infrequently used by the public and could be closed off to foot travel during the fungicide treatments. The treatment plots were located along Ash Hopper trail 0.25 to 0.50 miles from the junction of Ash Hopper trail and Highway 73 (across from the main entrance of the Sugarlands Visitor Center).

Sixteen dogwoods were selected and tagged for treatment with four separate fungicides, four trees per fungicide. Each set of trees was grouped by fungicide treatment to allow for more efficient foliar applications and to reduce the possibility of chemical drift to non-target

study trees. The trees selected for treatment were at least four meters in height (to insure an adequate canopy sample size) and no greater than eleven meters in height (to insure maximum coverage of the fungicide during foliar applications). All treatment trees were located in excess of eight meters from both Ash Hopper Branch and a smaller "feeder" stream as a precaution against possible water contamination. Seven additional dogwoods were selected and tagged to serve as untreated controls. Because chemical treatment was not involved, these trees were chosen regardless of their size or their proximity to nearby water sources.

The fungicides Zyban, Benlate, Daconil 2787, and Fore were chosen for the foliar treatments based on their effectiveness in anthracnose control in previous studies (Daughtrey et al., 1986 and Mielke et al., 1988) and were approved by the National Park Services' Integrated Pest Management Office for use in the Great Smokies. The fungicides were all wettable powders differing in chemical composition. Below is a list of the fungicides and their active ingredients:

Zyban	thiophanate methyl (15%), zinc ion and manganese ethylenebis dithiocarbamate (60%)
Benlate	benomyl (50%)
Daconil 2787	chlorothalnil (75%)
Fore	mancozeb (62%)

The application of the fungicides to the treatment trees required standard fire equipment: A 4x4 pumper truck with a large storage tank; a Mark III portable pump; and one-inch nylon fire hose with a high-pressure nozzle gun. The fungicides were mixed on location in separate 50-gallon plastic drums. The application rate (in accordance with the fungicide labels) for Zyban, Daconil 2787, and Fore was six ounces per 25 gallons of water; Benlate's rate of application was four ounces per 25 gallons of water. Thirteen drops of Triton B-1956, a spreader sticker, was added to each fungicide solution.

The treatment trees' foliage was sprayed until drip at approximately 15-day intervals, beginning May 8, 1989, and ending June 7, 1989, for a total of three fungicide applications. A fourth application was underway on June 23 when a heavy rain brought treatment to a halt prior to spraying the last set of trees with Fore.

Sampling

In order to determine the efficacy of the four fungicides, the study trees (treated and untreated) were evaluated using three sampling techniques at approximately one-month intervals: May 24, June 20, August 4, and September 13. The sampling data for each study tree included: (1) a Disease Severity Index score; (2) a count of the leaf lesions; and (3) an estimate of the percent lesion area for each leaf.

The first method of sampling required a visual inspection of each study tree in its entirety (canopy and stem). A score from the Disease Severity Index was then assigned to the tree as an evaluation of the tree's health.

The next method required the flagging of five branchlets of each study tree. The branchlets were selected for sampling if they could be easily reached by a telescoping tree pruning pole. All trees had a five branchlet sample with the exception of Daconil 2787 tree number 3, which had only one branch accessible by a pruning pole. Therefore, there was a 76 branchlet sample in the treatment group and a 35 branchlet sample in the control group. Twenty leaves on each branchlet were then evaluated for anthracnose lesions for a total of 2,220 leaves. Dogwood anthracnose lesions were distinguished from spot anthracnose lesions by their size, color, location on the branchlets, and their increase in growth as the season progressed. In addition, the necrotic tissue of the dogwood anthracnose lesions had a tendency to deteriorate creating holes in the infected leaves, whereas spot anthracnose lesions did not.

The evaluation of the percent leaf lesion area used the same branchlets and leaves as the previous evaluation. The percent of leaf area showing the symptoms of infection (leaf lesions) was estimated for each branchlet of 20 leaves for every study tree. The Apple Grower's index for estimating leaf lesions (Tehon and Stout, 1930) was used for reference.

The data from both the leaf lesion counts and the percent leaf lesion area were analyzed using a one-way analysis of variance (ANOVA). Differences were considered to be significant at the $P<0.05$ level. Tukey's (HSD) test was used to compare significantly different means.

Results/Discussion

Disease Severity Index

None of the study trees (treated or untreated) received a Disease Severity Index (DSI) score of 5 during the first evaluation, May 24. The treatment trees had initial ratings of 3 or 4, while the control trees received scores between 1 and 4 (Appendix 1).

The control trees showed more disease symptoms than did the treatment trees. Control #2 demonstrated a steady decline in health during the season. This tree received a score of 4 on May 24 and a score of 1 on the final evaluation day, September 13. In addition, Control #1 and Control #2 exhibited the first decline of all the study trees sampled.

According to the Disease Severity Index, Benlate #3 was the only tree that did not show a progression in disease symptoms. Benlate #3 remained relatively healthy (DSI=4) through the third month; its score was lowered to 3 by the final evaluation.

Fore #2 received the highest scores throughout the season. With the exception of the third rating in August, this tree received a score of 4

during each evaluation. It is probable that Fore #2 showed a marginal increase in symptoms towards the end of the season and a score of 3.5 (an average of the two scores) for August 4 and September 13 would have been appropriate.

The results from the DSI evaluation showed a general decline in vigor. We consider DSI a gross indicator, however, and performed no further analysis. We observed premature leaf abscission, as well as the deterioration of necrotic leaf tissue, which more than likely made our scores conservative.

Leaf Lesion Counts

The results from the one-way analysis of variance (ANOVA) indicate that there is a significant difference ($P<0.05$) in leaf lesion counts as a result of the fungicide treatments (Table 1). The mean leaf lesion count of the trees treated with Zyban and the trees treated with Daconil 2787 are similar (mean=1.57 and 1.52, respectively), but the mean leaf lesion count of the untreated control trees is higher (mean=1.98) than that of any of the treatment groups (Table 2).

The data in Table 2 shows the trees treated with Fore as having the lowest total mean leaf lesion count (mean=0.761) out of all the groups and Zyban as having the highest count (mean=1.57). This data needs to be interpreted carefully; when we evaluated the study trees we observed that the leaf lesions had a tendency to coalesce as the season progressed (signifying an increase in infection). Therefore, the data indicates a decrease in lesion counts when the lesion size had, in fact, increased.

Premature leaf abscission was an unanticipated problem. This was first observed in the June evaluation, when 54 percent of the control groups' branchlets had lost at least one leaf, and by September, 74 percent of the control branchlets showed some leaf drop. Among the treated trees, only three of the 76 branchlets exhibited some leaf drop in August, but by the September evaluation Benlate, Daconil 2787, and Fore branchlets showed 30 percent, 25 percent, and 30 percent leaf drop, respectively. Zyban exhibited no leaf abscission. Leaves on adjacent branchlets were assumed to be experiencing a similar level of infection, and were included as replacements in the study trees' twenty-leaf sample as appropriate. It is important to note that we observed extraordinary leaf drop in many of the other hardwood species as well. Acer rubrum and Liriodendron tulipifera demonstrated the greatest premature leaf drop. We attributed this phenomenon to factors related to the season's above average rainfall.

Percent Lesion Area Estimate

The results from the one-way analysis of variance (ANOVA) for the evaluation of percent lesion area indicate that there is a significant difference ($P<0.05$) in lesion area estimates as a result of the fungicide treatments (Table 1). The total mean percent lesion area of the trees treated with the fungicides are similar to one another, with values

Table 1. ANOVA Summary Tables

a. leaf lesion count

Source of Variation	df	Sum Squares	Mean Squares	F-test
Among groups	4	1849.138	462.284	181.987
Within groups	8638	21942.352	2.540	p=.000

b. leaf lesion estimate

Source of Variation	df	Sum Squares	Mean Squares	F-test
Among groups	4	39790.401	9947.600	25.147
Within groups	439	173661.822	395.585	p=.000

Table 2. Mean Number of Leaf Lesions of the Treatment Trees and Untreated Control Trees

Mean Number of Leaf Lesions

Data Collected	Zyban	Benlate	Daconil 2787	Fore	Control
1989					
[x] 24 May	0.610	0.242	1.04	0.240	1.43
20 June	1.19	0.756	1.63	0.725	2.25
4 August	1.52	1.02	1.56	0.947	1.77
13 September	2.98	1.88	1.84	1.13	2.46
[y] Total Mean	1.57[A]	0.975	1.52[A]	0.761	1.98
s	1.97	1.35	1.16	1.09	1.86

[x] For each row, there were 400 leaf counts (100/tree) per fungicide, 700 for controls. A total of 2,220 leaf data were collected for each of the four evaluation days.

[y] Means followed by the same letter do not differ significantly (p=0.05) according to Tukey's HSD test.

ranging from 11.2 (Benlate) to 23.6 (Daconil 2787) (Table 3), but the total mean percent lesion area for the control trees is the highest among all groups with a mean of 34.7. The data in Table 3 show the total mean percent lesion area of the trees treated with Benlate and Fore are lowest among the study trees (treated and untreated) with means of 11.2 and 13.5, respectively.

Premature leaf drop posed a similar problem with data collection in this evaluation. By August, we had included some "replacement" leaves in the sample. Again, adjacent branchlets appeared to be experiencing the same general level of infection.

Necrotic tissue deterioration was also problematical. It was more difficult to judge the area of infection after the dead tissue around the leaf margins had deteriorated. The leaf size was estimated through comparisons with adjacent leaves.

Conclusion/Recommendations

It is probable that the conditions in May, 1989, were ideal for infection--higher than average precipitation combined with relatively low temperatures (Table 4). After four years of drought conditions in the Great Smokies, the 1989 spring/summer season was extremely wet (Table 5); monthly rainfall averages at Park Headquarters were well above normal (GSMNP files).

The wet weather in June presented a problem in adhering to the recommended 10-day spray schedule. The weather dictated an approximate 15-day schedule and, as a result, a reduction in fungicide efficacy may have occurred. Regardless of the anomalous weather of 1989, any future studies should track disease progress on trees for more than one growing season. We also recommend fewer leaves (ten per branchlet) with each branchlet permanently marked to designate the ten-leaf sample. This would provide greater control in determining lesion growth and leaf abscission and would avoid the use of leaves on adjacent branchlets. If the leaf sample size is reduced, an additional branchlet per study tree is suggested.

The data indicate each of the four fungicides tested provided protection against the anthracnose fungus by reducing foliar symptoms. All treatment groups differed significantly from the control group at the five percent level.

Benlate and Fore demonstrated greater efficacy in the control of Discula than either Zyban or Daconil 2787. Benlate reduced the percent lesion area by 68 percent when compared with the untreated control group and Fore provided a 61 percent reduction in foliar symptoms. Zyban and Daconil reduced the foliar symptoms by 46 percent and 32 percent, respectively.

Table 3. Mean Percent Lesion Area of Leaves of Treatment Trees and Untreated Control Trees

Mean Leaf Lesion Area (%)

Data Collected	Zyban	Benlate	Daconil 2787	Fore	Control
1989					
[x] 24 May	4.15	1.40	6.69	0.85	10.7
20 June	3.00	2.30	7.47	2.60	23.3
4 August	32.8	18.1	41.3	23.6	48.6
13 September	32.8	23.0	39.1	27.0	56.2
[y] Total Mean	18.2^{ABCD}	11.2^{AD}	23.6^{B}	13.5^{CD}	34.7
s	18.4	14.4	18.8	16.7	24.9

[x] For each row, there were 400 leaf estimates (100/tree) per fungicide, 700 for controls. A total of 2,220 leaf samples was collected for each of the four evaluation days.

[y] Means followed by the same letter do not differ significantly (p=0.05) according to Tukey's HSD test.

AVERAGE WEEKLY TEMPERATURE AT PARK HEADQUARTERS, APRIL – AUGUST, 1989

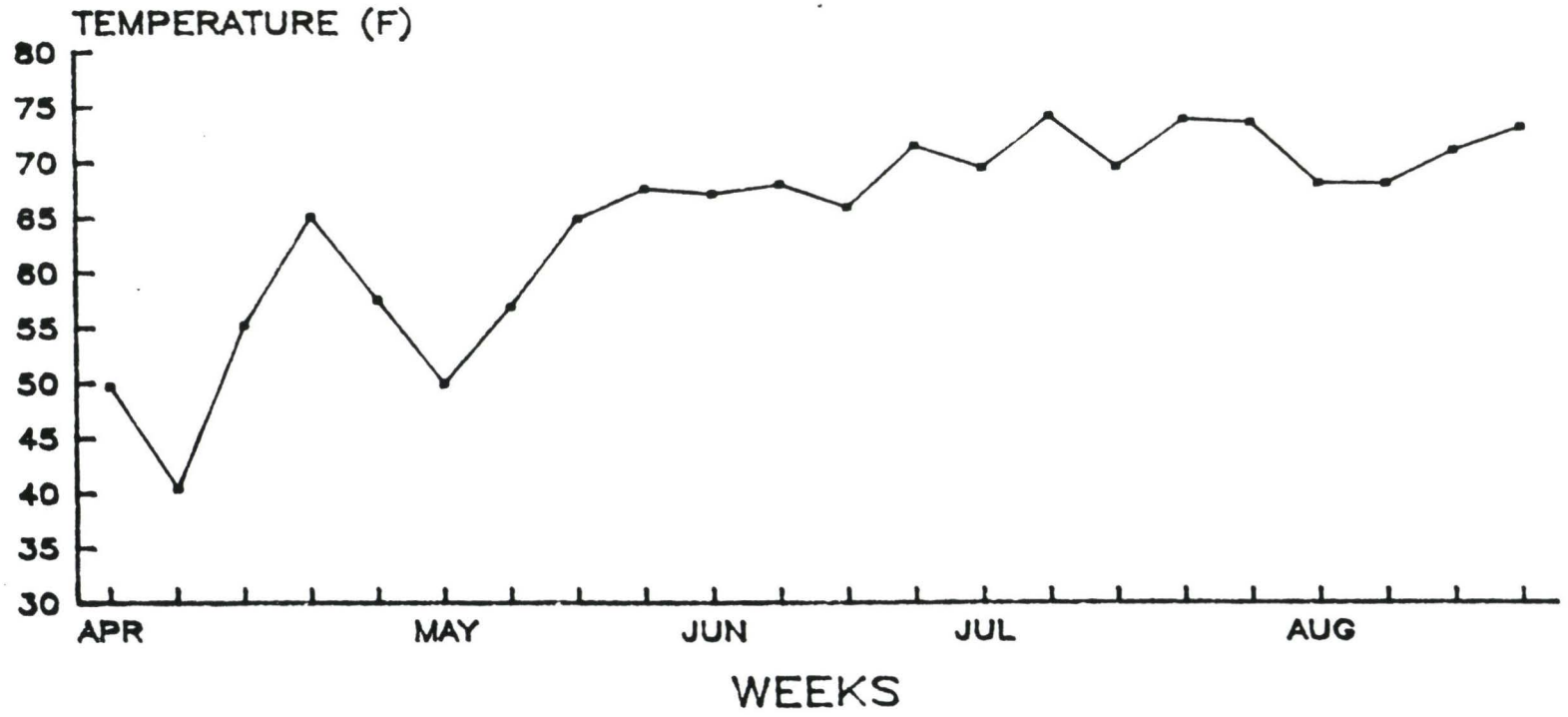

TABLE 4

PRECIPITATION AT PARK HEADQUARTERS
APRIL – AUGUST 1988/89

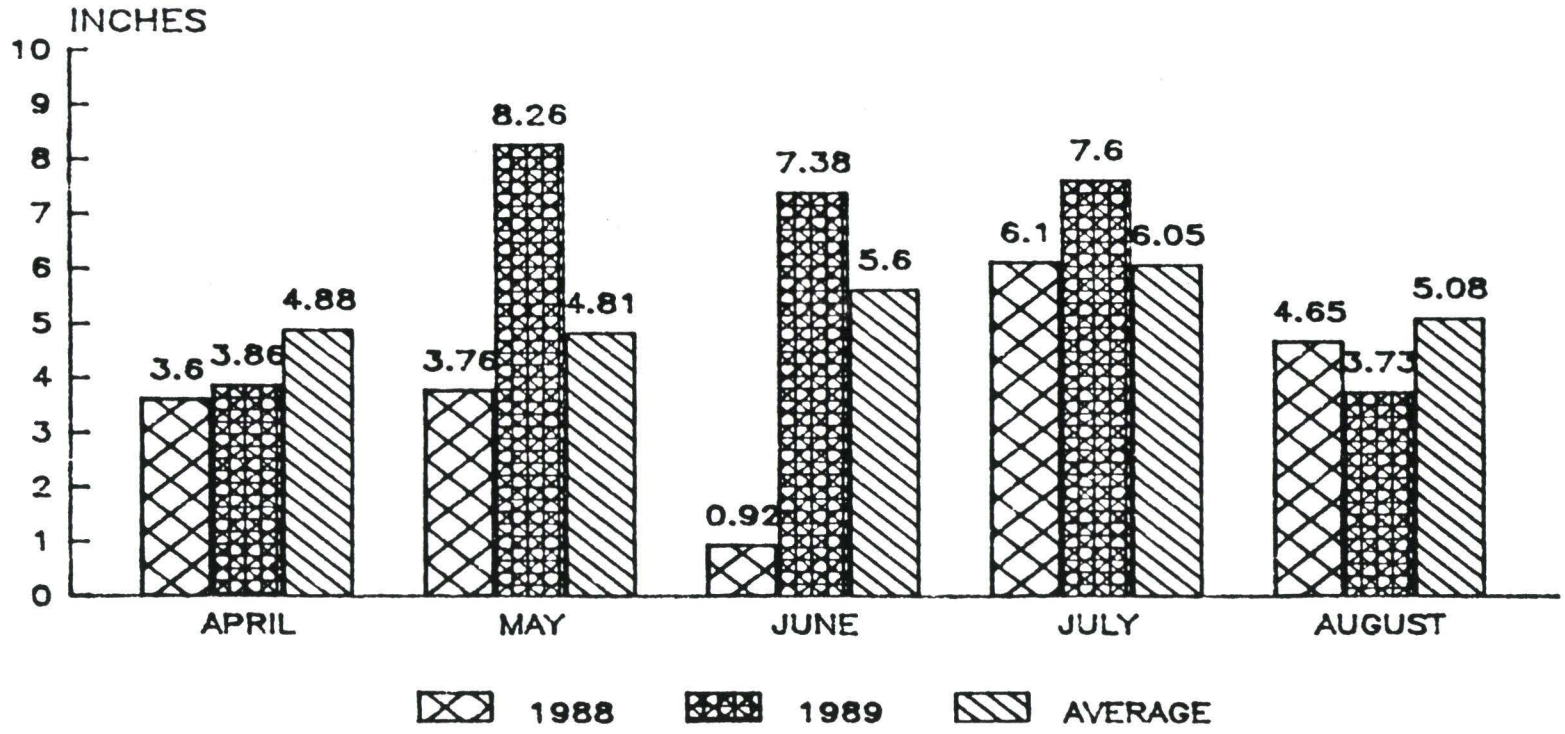

TABLE 5

PART II - Pruning Control

As stated in several recent USDA pamphlets and booklets, pruning of diseased twigs and branches may assist in providing an effective control for the anthracnose fungus (Mielke and Daughtrey, 1988, Bailey and Brown, 1989). This part of the program was designed to test the efficacy of pruning in a natural stand of C. florida.

Materials and Methods

Twenty-three pairs of C. florida, located in the Roaring Fork drainage of Great Smoky Mountains National Park, Sevier County, Tennessee, were selected for this field test. The study trees were scattered throughout a mixed-mesic hardwood forest within an elevation range of 2120 to 2280 feet. Several criteria were met in the selection process for the paired trees. The members of each pair were; (1) less than eight meters apart, (2) similar in DBH (<2 cm difference), and (3) exhibited similar disease symptomology.

On May 31, 1989, each tree was permanently tagged and one member from each pair was selected randomly for pruning. The incidence of epicormic sprouting in the study area was low which limited the initial tree selection process. In order to meet the stated selection criteria, none of the pair members displayed this disease symptom. The absence of shoots during the study season restricted the pruning process to infected twigs and branches only. Pruning was done with lopping shears and the pruned portions were placed in plastic bags and discarded.

All study trees were evaluated and the selected pair members were pruned on the following days: May 31, June 23, July 14, and August 3, 1989. The evaluation included; (1) assigning a Disease Severity Index (DSI) score, and (2) estimating the percent lesion area of a ten-leaf sample of each pair member using the Apple Growers index (Tehon and Stout, 1930) as reference. The location of the ten-leaf sample varied on each tree (pruned pair member only) due to the removal of infected branches. The data were analyzed according to paired t-test ($P<0.01$).

Results/Discussion

According to the DSI evaluation, all of the 46 study trees showed similar levels of infection with scores of four. The disease symptoms apparently did not increase as the season progressed. All trees received a rating of four at the final evaluation on August 3.

The results from the paired t-test did not indicate a significant

difference (<0.01) in percent leaf lesion estimates between pruned pair members and the unpruned trees. On August 3, the mean percent leaf lesion area for the 23 pruned trees was 4.0 percent and the 23 unpruned trees had a mean percent lesion area of 6.0. Since there was no difference between treatments, the root starch analysis was not performed.

Conclusion/Recommendations

Disease dispersal from adjacent trees may well be enough to overwhelm the single trees used in this effort. This project should be repeated using contiguous trees in sites rather than single trees. As in the fungicide testing portion (Part I) of this study, difficulties were encountered in obtaining precise disease impact data on foliage. A better method would be to increase the number of dogwoods and area treated by pruning, and monitor for several years for progression of DSI and mortality.

Appendix 1. Disease Severity Index Scores for Treated and Untreated Control Trees

Data Collected	Tree	Disease Severity Index: Zyban	Benlate	Daconil 2787	Fore	Control
1989						
24 May	1	4	4	4	4	4
	2	4	4	3	4	4
	3	3	3	4	4	3
	4	4	4	3	3	4
	5	-	-	-	-	2
	6	-	-	-	-	1
	7	-	-	-	-	3
20 June	1	4	4	4	4	3
	2	4	4	3	4	3
	3	3	3	4	4	3
	4	4	4	3	4	4
	5	-	-	-	-	2
	6	-	-	-	-	2
	7	-	-	-	-	3
4 August	1	3	4	3	3	3
	2	3	4	3	3	2
	3	3	3	3	3	2
	4	3	2	2	3	3
	5	-	-	-	-	2
	6	-	-	-	-	2
	7	-	-	-	-	2
13 September	1	3	2	2	3	2
	2	2	3	2	4	1
	3	2	3	2	2	1
	4	2	2	2	2	3
	5	-	-	-	-	1
	6	-	-	-	-	1
	7	-	-	-	-	2

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DOGWOOD ANTHRACNOSE PAIRED TREE PRUNING EVALUATION - 1989

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Report #89-1-35
November 1989

DOGWOOD ANTHRACNOSE PAIRED TREE PRUNING EVALUATION - 1989

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DOGWOOD ANTHRACNOSE PAIRED TREE PRUNING EVALUATION - 1989

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ABSTRACT

A dogwood anthracnose paired tree pruning evaluation of the flowering dogwood (Cornus florida L.), was put in the Bent Creek Experimental Forest in April, 1989. One tree of each pair was pruned by removing all dead wood and all epicormic shoots each month. There was no difference in severity of infection between the pruned and nonpruned trees.

INTRODUCTION

A new disease, dogwood anthracnose was found in the late 70's - early 80's causing severe foliage symptoms, and killing the flowering dogwoods (Cornus florida L. and C. nuttallii). The disease was found to be caused by an unidentified species of the fungus Discula (1,2). Symptoms of Discula sp. infection are: beginning in the lower part of the tree, yearly twig and branch dieback; purple rimmed leaf spots (larger than spot anthracnose) and leaf blotch (some blotched leaves will be retained by the tree throughout the winter); epicormic shoots are produced, become infected and die back; annual cankers are formed where epicormic shoots dieback to the main stem or branch and the fungus grows into them. When enough cankers are formed, the tree or branch is girdled and dies. On young plants, enough leaves and twigs can be infected to cause death without canker formation.

All sizes and ages of dogwoods are susceptible. The disease is more severe in forest settings at high elevations and where conditions are moist and cool. Infected understory dogwoods can die in 2 to 5 years, whereas trees in open areas may live a long time.

At this time in the Southeast, the disease has been found in 84 counties over 7 states and affecting an estimated 2.2 million acres (4).

One of the recommended cultural practices (2) to help control the disease is pruning out all dead wood and epicormic shoots. A pruning study was put into a forest setting to look at its affect on the disease under ideal conditions for the fungus.

METHODS

Forty paired flowering dogwoods (Cornus florida L.) were selected at the Bent Creek Experimental Forest in April, 1989. The following criteria was used to select the paired trees:

All trees were between 2 and 12 feet tall.

All trees were relatively free of other damage.

All trees were located at least 66 feet from any road.

Each tree of a pair was within one foot of each other in height.

Each tree of a pair was within 50 feet of each other.

Each tree of a pair had approximately the same degree and type of symptoms.

All symptom data were collected according to the Mielke and Langdon method (3):

Tree Class No.		Symptom
0	=	Dead
1	=	> 75% of Foliage affected
2	=	51-75% of Foliage affected
3	=	26-50% of Foliage affected
4	=	1-25% of Foliage affected
5	=	Healthy

All trees were scored at the start and then one tree of each pair was pruned of all dead wood and epicormic shoots.

Approximately once a month the paired trees were revisited and scored. The pruned trees were pruned of any new dead wood or epicormic shoots. The study ended in September, 1989.

RESULTS AND DISCUSSION

There was no difference in the amount of dogwood anthracnose symptoms between the pruned and the non pruned trees (Table 1). This may have been caused by the close proximity to other infected trees. If trees in a large area had been pruned it may have been more effective.

There was a decrease in the number of trees in the 51 percent and greater severity classes and an increase in the 1 to 50 percent classes. This may be an indication that a lot of the heavily infected leaves may drop off prematurely giving the look of a healthier tree.

Control of dogwood anthracnose in the forest setting is not practical at this time. However, there are some ornamental settings that are similar to a forest where pruning would be practical. This pruning study did not show any difference during one growing season. This does not mean positive results would not be seen next year. The real benefit may be the removal of epicormic shoots to prevent the fungus from entering the stem. This evaluation or a modification of this evaluation will continue for 2 more years with special emphasis on the epicormic shoot pruning.

Table 1. Percent of Trees in Different Dogwood Anthracnose Severity Classes - September 1989

	> 75% [1]		51-75%		26-50%		1-25%		Healthy		Average	
	Pruned	Not Pruned	Pruned	Not Pruned	Pruned	Not Pruned	Pruned	Not Pruned	Pruned	Not Pruned	Pruned	Not Pruned
Start of Study	10	10	15	15	28	28	48	48	0	0	20.2	20.2
End of Study	3	3	0	8	45	35	53	55	0	0	20.2	20.2

[1] See text for the classifications.

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ACKNOWLEDGEMENT

Thanks to Tom McCartney (Forestry Technician, USDA Forest Service, Forest Pest Management) for the pruning and data collection.

EFFECTS OF DIFFERENT FERTILIZERS AND THE FUNGICIDE DACONIL ON FLOWERING DOGWOODS INOCULATED WITH THE DOGWOOD ANTHRACNOSE FUNGUS

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Report 90-1-16
February 1990

EFFECTS OF DIFFERENT FERTILIZERS AND THE FUNGICIDE DACONIL ON FLOWERING DOGWOODS INOCULATED WITH THE DOGWOOD ANTHRACNOSE FUNGUS

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EFFECTS OF DIFFERENT FERTILIZERS AND THE FUNGICIDE DACONIL ON FLOWERING DOGWOODS INOCULATED WITH THE DOGWOOD ANTHRACNOSE FUNGUS

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ABSTRACT

Five different fertilizer and two fungicide treatments were applied on greenhouse grown flowering dogwood (Cornus florida L.) seedlings inoculated with the dogwood anthracnose fungus (Discula sp.). There was a clear interaction between the treatments and symptom development. Phosphorus appeared to increase symptom development while nitrogen increased shoot mortality. The fungicide Daconil 2787, was most effective in reducing disease severity when applied at 14 day intervals. This pilot test shows there is a correlation between nutrients and dogwood anthracnose and additional work is needed to clarify cause/effect. It also showed that Daconil is effective in reducing disease symptoms under greenhouse conditions.

INTRODUCTION

Dogwood anthracnose (caused by Discula sp.) was first found in the late 70's killing flowering dogwoods (Cornus florida L. and C. nuttallii). This new disease continues to spread in the Eastern United States. At this time dogwood anthracnose has been found in eighty four counties over 7 states in the southeast. There is little information about how the fungus spreads over long distances.

A reliable inoculation procedure was worked out using a pre-treatment of pH 2.8 hydrochloric acid sprayed on the seedlings and then the fungus. With this information, past control recommendations could be evaluated under greenhouse conditions. One of the recommendations was to fertilize with a fertilizer of low nitrogen to reduce epicormic shoot development. Also, that the application of the fungicide clorothalonil (Daconil 2787) was effective in reducing disease severity.

This pilot test was conducted in August 1989 to evaluate the effect of different fertilizers on the Discula sp. fungus and the benefit of Daconil 2787 in reducing disease severity.

METHODS

Three hundred, one to three inch flowering dogwoods were transplanted from the South Carolina Forestry Commission's Piedmont Nursery into 4 inch pots. The planting medium was Metro-mix 300 growing medium.

Three months later when the seedlings were about 18 inches high ten groups of 24 uniform seedlings were chosen. The groups were divided into inoculated and non-inoculated and treated as follows:

NO. SEEDLINGS INOCULATED	FERTILIZER AND FUNGICIDES N P K	NO. SEEDLINGS NON-INOCULATED
12	16-00-00	12
12	00-00-60	12
12	00-46-00	12
12	LIME	12
12	10-10-10	12
12	CONTROL	12
12	10-10-10 + DACONIL - 7 DAYS	12
12	10-10-10 + DACONIL - 14 DAYS	12
96	TOTAL SEEDLINGS	96

One eighth teaspoon of fertilizer was put onto the planting medium of each seedling and watered-in. No additional fertilizer was applied during the evaluation. The fungicide concentration was 1 tablespoon per gallon of water. It was sprayed onto the seedlings to the point of run off with a hand held sprayer. The seedlings were watered as needed.

Forty one days after the start of the treatments; Day 1 - all seedlings were put into plastic bags in groups of four and sprayed with a pH 2.8 hydrochloric acid mist and the bags sealed with a wire tie.

Day 2 - the non-inoculated groups of seedlings were sprayed with a deionized water mist and the inoculated groups were sprayed with a Discula sp. conidal dilution of 2000 spores per milliliter. Days 1 and 2 procedures were repeated on days 3 and 4. The dogwoods were held in a room with incidental sun light and the temperature was maintained at 70°F. The bags were opened each week and the seedlings were sprayed with a deionized water mist.

The spore dilution was made from five Discula sp. isolates obtained from diseased dogwoods in Georgia, North Carolina, Tennessee, and Virginia. The isolates were each grown on fresh acidified potato dextrose agar with a sterilized dogwood leaf in each petri dish. Incubation time was three weeks at 18-23°C and under normal laboratory light. Conidia were washed from the petri dishes of each isolate with sterile distilled water and in equal concentrations and portions, mixed together.

Thirty four days after inoculation the non-inoculated seedlings were evaluated for symptoms. The total number of leaves and number of symptomatic leaves, potentially caused by Discula sp., were recorded and removed. The percentage of leaf area affected (severity) was estimated and examined microscopically for the presence of Discula sp. fruiting.

Samples of the planting medium from two seedlings of each treatment were collected for soil testing.

The inoculated seedlings were evaluated the same as the non-inoculated except attached symptomatic leaves were not removed for microscopic examination, only those that had fallen off were microscopically examined.

Fifty four days after inocuation, the inoculated seedlings were evaluated for terminal and lateral dieback. The total millimeters of terminal dieback, the number of laterals infected per seedling, and the total millimeters of lateral dieback per seedling were recorded.

RESULTS AND DISCUSSION

For inoculated seedlings, phosphorus treatment (00-46-00) averaged about seventy percent of the foliage showing symptoms (Table 1). This was significantly higher than any of the other treatments. Nitrogen, potassium and lime did not significantly affect the percent of leaves with symptoms. Both Daconil treatments resulted in a significant reduction in percent of leaves with symptoms (Table 3). The same trends followed for the non-inoculated seedlings but less than one percent of the seedlings were positive for Discula sp. (Table 1).

The same trends followed for the average percent of leaf area affected with the exception of Daconil at 7 days application. It did show a significant reduction but not as good as the 14 day treatments (Table 1 and 4). The reason for this is unknown.

The inoculated trees were observed for shoot dieback. In this case phosphorus treated trees had the lowest shoot dieback. The other trends are unclear but it appears that nitrogen and Daconil treated seedlings had increased shoot dieback (Table 2).

These results show that phosphorus increased leaf infection while Daconil reduced leaf infection and nitrogen did not influence infection. However, shoot dieback was increased by nitrogen and Daconil applications but reduced by phosphorus.

Basically, these data show that there is an interaction between fertilizer and infection. This is further, compounded by Daconil reducing infection but increasing shoot dieback. This makes it clear that these results need to be evaluated under controlled pilot test field conditions.

The lesson to be learned from this pilot test is that there is a reaction and we need to be careful with recommendation until large scale pilot tests are completed.

Table 1.--Percent of symptomatic leaves and confirmed discula sp. and average severity on both inoculated and non-inoculated seedlings by fertilizer and fungicide treatments. Also, the soil analyses for the different treatments.

TREATMENTS	% SYMPTOMATIC		% DISCULA SP.		AVG. SEVERITY		SOIL			
							pH	P	K	Zn
	N[1]	I[1]	N	I	N	I	-------	ppm	---------	
16-00-00	28	32	1	33	30	52	5.9	068	78	060
00-00-60	25	33	1	22	62	54	6.2	078	124	066
00-46-00	75	70	0	38	85	86	5.8	159	64	094
10-10-10	46	29	0	40	59	51	5.6	106	90	062
LIME D7[2]	33	37	0	29	38	41	6.1	047	60	500
10-10-10 D14[2]	11	17	0	19	26	36	5.3	109	122	058
10-10-10	10	10	0	70	13	11	5.4	106	116	058
CONTROL	24	25	0	29	39	51	5.8	082	102	067

1) N = NON-INOCULATED; I = INOCULATED
2) D = DACONIL; 7 = APPLIED EVERY 7 DAYS; 14 = APPLIED EVERY 14 DAYS

Table 2.--Percent and Growth of Terminal and Lateral Dieback on Seedlings Inoculated with *Discula Sp.* and Treated with Different Fertilizers and a Fungicide.

TREATMENTS	% TREES TERMINAL DIEBACK	AVERAGE MM INFECTION	% TREES LATERAL DIEBACK	AVERAGE # LATERAL LATERALS/ SEEDLING INFECTED	AVERAGE MM/ LATERAL INFECTED	AVERAGE MM OF LATERAL INFECTED/ SEEDLING
D7[1]	75	121	92	3	62	175
D14[1]	82	68	100	3	59	199
00-46-00	25	19	42	0.5	31	16
16-00-00	91	68	91	4	53	182
00-00-60	42	22	75	2	42	8
LIME	58	35	50	1	80	53
10-10-10	38	38	81	3	56	143
CONTROL	50	32	67	3	47	121

1) D = DACONIL 2787; 7 = APPLIED EVERY 7 DAYS; 14 = APPLIED EVERY 14 DAYS

Table 3.--Analysis of Variance and Duncon's Multiple Range Test for Dogwood Anthracnose Symptomatic Leaves on Dogwood Seedlings Inoculated with the Discula Sp. Fungus.

ALPHA = 0.05		DF = 88	MSE = 318.14	
NUMBER OF MEANS	2	3	4	5
CRITICAL RANGE	14.4877	15.2345	15.7176	16.0763
NUMBER OF MEANS	6	7	8	
CRITICAL RANGE	16.3777	16.6238	16.8248	

Means with the same letter are not significantly different.

TREATMENT	N	MEAN	DUNCON GROUPING		
00-46-00	12	73.743	A		
00-00-60	12	39.387	B		
LIME	12	37.178	B		
16-00-00	12	33.805	B	C	
10-10-10	12	30.787	B	C	
CONTROL	12	27.853	B	C	D
DACONIL 7*	12	19.200		C	D
DACONIL 14*	12	14.147			D

*DACONIL 2787; 7 = Applied every 7 days; 14 = Applied every 14 days

Table 4.--Analysis of Variance and Duncon's Multiple Range Test for Severity of Dogwood Anthracnose Symptoms on Dogwood Seedlings Innoculated with the Discula Sp. Fungus.

	ALPHA = 0.05	DF = 88	MSE = 263.163	
NUMBER OF MEANS	2	3	4	5
CRITICAL RANGE	13.1766	13.8558	14.2952	14.6214
NUMBER OF MEANS	6	7	8	
CRITICAL RANGE	14.8956	15.1193	15.3022	

Means with the same letter are not significantly different.

TREATMENT	N	MEAN	DUNCON GROUPING
00-46-00	12	86.250	A
00-00-60	12	61.250	B
LIME	12	54.167	B
16-00-00	12	52.083	B
10-10-10	12	50.833	B
CONTROL	12	50.833	B
DACONIL 7*	12	36.250	C
DACONIL 14*	12	10.833	D

*DACONIL 2787; 7 = Applied every 7 days; 14 = Applied every 14 days

EFFECT OF LEAF WOUNDING AND FUNGICIDE APPLICATIONS ON INFECTION BY THE DOGWOOD ANTHRACNOSE FUNGUS, UNDER GREENHOUSE AND LABORATORY CONDITIONS

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Asheville Field Office

Report 89-1-29
September 1989

EFFECT OF LEAF WOUNDING AND FUNGICIDE APPLICATIONS ON INFECTION BY THE DOGWOOD ANTHRACNOSE FUNGUS, UNDER GREENHOUSE AND LABORATORY CONDITIONS

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ABSTRACT

Dogwood anthracnose (caused by Discula sp.) symptom development was evaluated among greenhouse-grown Cornus florida L. seedlings exposed to Discula sp. spores after wounding the leaves with carborundum or treating the leaves with the fungicide chlorothalonil (Danconil). The percentage of leaves infected and the severity of symptom development on infected leaves decreased about 70 percent with fungicide treatment. Wounded leaves had a small increase in the percentage of leaves with symptoms. These data show that wounding can increase infection and chlorothalonil can significantly reduce infection under laboratory conditions that favor the fungus.

INTRODUCTION

Dogwood anthracnose (caused by Discula sp.) is the most damaging disease of (Cornus florida L.) in a large part of the tree's range. Foliage leaf spots, leaf blight, shoot dieback and death are typical symptoms of this disease. Dogwood anthracnose has spread rapidly since it was first reported in Northeastern United States 1983. By 1989, a working group of federal and state employees found the disease in 80 counties in seven southern states. This disease can kill a large percentage of the dogwoods in an area; for example, Langdon, Schneeberger and Jackson reported 33% mortality for the dogwoods in Catoctin Mountain Park, Maryland in 1984 and 79% in 1988.

A previous investigation established procedures for inoculating healthy dogwood seedlings. Using these procedures, trees were treated with Discula sp., after being treated with simulated acid rain, and the fungicide chlorothalonil or surface wounding with carboruadum. The purpose was to see if this registered fungicide would reduce infection under greenhouse conditions and if leaf wounding would increase infection.

Materials and Methods

A mixture of peat moss, perlite, and pasturized top soil (5:4:3 by volume) was uniformly blended and divided in half. The pH of this mixture was 4.6. The pH of half of the growing medium was adjusted to 5.6 using hydrated lime. Four-hundred dormant, one-year-old dogwoods were transplanted in each mixture in one-liter containers. The seedlings had been grown at the Georgia Forestry Commission's nursery in Byron, Georgia and had been in cold storage for two

months. After transplanting, the seedlings were placed in trays that held four containers and moved to a greenhouse. Temperatures ranged from 20 to 30°C and they were watered with tap water until leaves started to develop. The seedlings were fertilized (15-30-15) with a liquid solution one week and two weeks after transplanting. No additional fertilizer was applied during the study and the seedlings received only natural sunlight.

Simulated rain was applied using rain tables that are based on the principle of droplet formation from needle points. The simulated rain was prepared using the composition described by Shafer and others which includes the ions characteristic of natural rainfall. The pH of the simulated rain was adjusted using a 1 N mixture of sulfuric and nitric acids (70 mEq SO_4: 30 mEq NO_3.

Once leaf development had started, 320 seedlings (160 for each growing medium pH) were selected for uniformity of leaf development and divided equally among four simulated rain treatments: pH 2.5, 3.5, 4.5, and 5.5. The seedlings were exposed to one cm of simulated rain on ten dates over a 42 day period. On three occasions, additional simulated rainwater of the appropriate pH was applied by hand directly to the growing medium to maintain adequate levels of moisture. A completely randomized experimental design was used with a tray of four seedlings being the experimental unit. After each rain event, the position of the trays was rerandomized on the greenhouse benches.

After ten simulated rain treatments had been applied, all seedlings were evaluated for abnormal leaf symptoms. All of the seedlings exposed to simulated rain with a pH of 2.5 had small circular necrotic lesions (1-3 mm). Six of the limed seedlings were discarded because they had marginal leaf necrosis. All remaining seedlings had normal leaves. Two of the 5.5 pH and two of the 2.5 pH trays were removed for use in these evaluations. Twenty-four hours prior to Discula inoculation all seedlings were moved to a laboratory with low light levels and temperatures of about 20°C. Each tray of seedlings was placed in a separate, clear plastic bag with bamboo stakes to keep the plastic away from the leaves. The leaves for the pH 2.5 acid rain treatment were sprayed with Chlorothalonil at the registered label rate and the leaves from the tray sprayed with simulated 5.5 acid rain were wounded with carborundum. Each bag was sealed with a twist tie. A companion set of trees received only deionized water.

Five Discula sp. isolates were obtained from diseased dogwoods in Georgia, Virginia, North Carolina, and Tennessee and cultured separately using potato dextrose agar with a sterilized dogwood leaf in each petri plate. From isolation to spore recovery, the cultures were maintained under laboratory light at 18-24°C.

The trays of seedlings in all treatment combinations were inoculated in the same fashion. On the first day of the inoculation procedure, spores from each of the five isolates were washed into separate flasks of distilled (5.8 pH) water, diluted to 50,000 spores/ml and sprayed as a mist on the leaves of the trees designated to be inoculated. On the second day the trees were misted with deionized water. On the third day the whole process of preparing spore suspensions was repeated, except the concentration was adjusted to 2,500 spores/ml. Once a week thereafter, all seedlings were misted with deionized water and the position of bags were rerandomized.

The seedlings were evaluated for infection 28 days after inoculation by an observer who was unaware of the treatment. All leaves with necrotic areas potentially caused by Discula were removed from each seedling and counted. The percentage of leaf area affected on the symptomatic leaves was then estimated to the nearest five percent. All of the affected leaves, or the ten most severely affected leaves if more than ten showed symptoms, were examined microscopically for the presence of Discula. All nonsymptomatic leaves (acid-caused lesions were not considered symptomatic unless fungal infection was apparent) were counted. The total number of leaves, the percentage of symptomatic leaves, severity of symptoms, and the percentage of leaves on which Discula sp. confirmed were calculated for each seedling.

A t-test was used to determine if the effects were statistically significant.

Results and Discussion

These inoculation and incubation procedures are a reliable method for inducing symptoms of dogwood anthracnose in healthy seedlings. In some treatment combinations every seedling showed symptoms of the disease. Discula was confirmed on 83% of the symptomatic leaves of inoculated trees. Many of the symptomatic leaves on which Discula was not confirmed were in advanced stages of development or appeared to be new infections. From previous laboratory work, these types of leaves normally yield Discula sp. when incubated. This was not done because of the high recovery rate on harvested leaves and the volume of material to process. Since the data analysis showed a close association between symptom expression and the presence of Discula, we elected to analyze the former.

For both the limed and unlimed soil media, Chlorothalonil resulted in about a 70 percent reduction in symptom development, which was significant at the 99 percent level of confidence (Table 1). There was no significant difference in severity on the affected leaves for either soil type (Table 2). These data are very close to field data from the northeastern U.S. that show an 80 percent reduction in symptom development.

For the limed soil media, the leaf wounding did not produce a significant response. For the unlimed soil there was a significant increase in symptoms as a result of the carborundum treatment (Table 1). However, the increase from 0 to 9 percent is not considered to be biologically significant. Wounded leaves from the limed soil did show an increase in the percentage of leaf area affected (Table 2).

These results show that Chlorothalonil can significantly reduce dogwood anthracnose symptoms under greenhouse conditions, even when environmental conditions favor the fungus. It also shows that wounding can increase symptom expression, but not to a large degree.

Table 1 - Percentages of leaves showing symptoms of dogwood anthracnose after seedlings growing in limed and non-limed media were exposed to Discula sp. spores, fungicide treatment and leaf wounding.

Treatment	Limed Soil	Non-Limed Soil
	- - - - - - % Leaves Affected - - - - - -	
Chlorothalonil	14	4
No Chlorothalonil	52	14
Leaf Wounding	8	9
No Leaf Wounding	6	0

Table 2 - Average leaf areas of affected leaves showing symptoms of anthracnose after dogwood seedlings growing in limed and non-limed media were exposed to Discula sp. spores, fungicide treatment and leaf wounding.

Treatment	Limed Soil	Non-Limed Soil
	- - - - - - % of Leaf Area - - - - - -	
Chlorothalonil	59	77
No Chlorothalonil	62	55
Leaf Wounding	40	58
No Leaf Wounding	20	N/A

DOGWOOD ANTHRACNOSE SYMPTOMS ARE INCREASED BY APPLICATION OF SIMULATED ACIDIC PRECIPITATION

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Dogwood Anthracnose Symptoms Are Increased By Application Of Simulated Acidic Precipitation

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Anderson, Robert L., Paul Berrang, John Knighten, and K. Ann Lawton. 1989. Dogwood anthracnose symptoms are increased by application of simulated acidic precipitation. Can. J. For. Res.

Dogwood anthracnose (caused by Discula sp.) symptom development was evaluated on greenhouse-grown Cornus florida L. seedlings exposed to Discula sp. spores and four acidities of simulated rain. The percentage of leaves infected and the severity of symptom development on infected leaves increased with decreasing rain pH. The effect of adjusting the pH of the growing medium was also evaluated, and there was less symptom development on seedlings grown in the more acid medium.

Introduction

Dogwood anthracnose (caused by Discula sp.) is the most damaging disease of flowering dogwood (Cornus florida L.) in a large part of the tree's range. Foliage leaf spots, leaf blight, shoot dieback, and death are typical symptoms of this disease. Dogwood anthracnose has spread rapidly since it was first reported in the northeastern United States in 1983 (Daughtrey and Hibben 1983). By 1989, a working group of federal and state employees found the disease in 83 counties in 7 southern states. This disease can kill a large percentage of the dogwoods in an area. For example, Mielke and Langdon (1986) and Schneeberger and Jackson (1989) reported 33% mortality of dogwoods in Catoctin Mountain Park in Maryland in 1984 and 79% in 1988.

Anderson (1989) established that healthy seedlings were most often artificially infected after pretreatment with water that had been acidified to a pH of 2.8 with hydrochloric acid. This information, combined with unpublished field surveys which found the disease primarily in the areas reported to have the lowest pH precipitation (NAPAP 1987), suggested that acidic rainfall could predispose dogwoods to this disease. In the study described here, we evaluated the effects of differences in the pH of simulated rainfall on the severity of infection of young dogwood leaves after inoculation with pure cultures of Discula.

Materials and Methods

A mixture of peat moss, perlite, and pasteurized topsoil (5:4:3 by volume) was uniformly blended and divided in half. The pH of this mixture was 4.6. The pH of half of the growing medium was adjusted to 5.6 by adding hydrated lime. Two-hundred dormant, 1-year-old dogwoods were transplanted into individual 1-L tubes containing each mixture. The seedlings had been grown at the Georgia Forestry Commission's nursery in Byron, Georgia, and had been in cold storage for 2 months. After planting, the seedlings were placed in trays that held four tubes and moved to a greenhouse. Temperatures ranged from 20 to 30°C, and they were watered with tap water until leaves started to develop. The seedlings were fertilized (15-30-15) with a liquid solution 1 week and 2 weeks after transplanting. No additional fertilizer was applied during the study and the seedlings received only natural sunlight.

Simulated rain was applied using rain tables similar to those developed by Chevone et al. (1984) that are based on the principle of droplet formation from needle points. Ion composition of the simulated rain was made up as described by Shafer et al. (1985). The pH of the simulated rain was adjusted with a 1 N mixture of sulfuric and nitric acids (70 mEq SO_4 : 30 mEq NO_3).

Once leaf development started, 320 seedlings (160 for each growing medium pH) were selected for uniformity of leaf development and divided equally among four simulated rain treatments: pH 2.5, 3.5, 4.5, and 5.5. The seedlings were exposed to 1 cm of simulated rain on 10 dates over a 42 day period. On three occasions, additional simulated rainwater of the appropriate pH was applied by hand directly

to the growing medium to maintain adequate moisture. A completely randomized experimental design was used with a tray of four seedlings being the experimental unit. After each rain event, the position of the trays was rerandomized on the greenhouse benches.

After 10 simulated rain treatments, all seedlings were evaluated for abnormal leaf symptoms. All of the seedlings exposed to simulated rain with a pH of 2.5 had small circular necrotic lesions (1-3 mm). Six of the limed seedlings were discarded because they had marginal leaf necrosis. All remaining seedlings had normal leaves. Two of the 5.5 pH and two of the 2.5 pH trays were removed for use in separate studies. Twenty-four hours prior to Discula inoculation, all seedlings were moved to a laboratory with low light levels and temperatures of about 20°C. Each tray of seedlings was placed in a separate, clear plastic bag with bamboo stakes to keep the plastic away from the leaves. The leaves were sprayed with deionized water and each bag was sealed with a twist tie.

Five Discula sp. isolates were obtained from diseased dogwoods in Georgia, North Carolina, and Tennessee and cultured separately on potato dextrose agar with a sterilized dogwood leaf in each petri plate. Representative cultures were confirmed as Discula sp. by Margery Daughtrey of Cornell University. From isolation to spore recovery, the cultures were maintained under laboratory light at 18-24°C.

The trays of seedlings in all treatment combinations were equally and randomly divided into inoculated and noninoculated treatments. On the first day of the inoculation procedure, spores from each of the five isolates were washed into separate flasks of distilled (5.8 pH)

water, diluted to 50,000 spores/mL, and sprayed as a mist on the leaves of the trees designated to be inoculated. Seedlings that were not scheduled for inoculation received a deionized water mist. On the second day, all seedlings were misted with deionized water. On the third day, the whole process of preparing spore suspensions was repeated, except the concentration was adjusted to 2,500 spores/mL. Once a week thereafter, all seedlings were misted with deionized water and the positions of bags were rerandomized.

The seedlings were evaluated for infection 28 days after inoculation by an observer who was unaware of the treatment. All leaves with necrotic areas potentially caused by Discula were removed from each seedling and counted. The percentage of leaf area affected on the symptomatic leaves was then estimated to the nearest 10%. All of the affected leaves, or the 10 most severely affected leaves if more than 10 showed symptoms, were examined microscopically for the presence of Discula. All nonsymptomatic leaves were counted Acid-caused lesions were considered symptomatic only if fungal infection was apparent. The total number of leaves, the percentage of symptomatic leaves, the severity of symptoms, and the percentage of leaves on which Discula sp. infection was confirmed were calculated for each seedling.

An arc sine transformation was used to correct for lack of normality, and the data were subjected to standard analysis of variance. Very strong interactions among the three main effects made it necessary to analyze the data as a series of separate studies. Duncan's multiple-range test was used to evaluate the significance of differences between treatment levels.

Results and Discussion

The inoculation and incubation procedures proved reliable for inducing symptoms of dogwood anthracnose in healthy seedlings. In some treatment combinations, every seedling showed symptoms of the disease. Discula was confirmed on 83% of the symptomatic leaves of inoculated trees. Many of the symptomatic leaves on which Discula was not confirmed were badly deteriorated or appeared to have new infections. From previous laboratory work, these types of leaves normally yield Discula sp. when incubated. This was not done because of the high recovery rate on harvested leaves and the volume of material to process. Since the data analysis showed a close association between symptom expression and the presence of Discula, we elected to analyze the former.

The percentage of leaves with symptoms of dogwood anthracnose increased as the acidity of the simulated rain applied to the seedlings increased. Analyses of the effects of differences due to the pH of simulated rain on the percentage of symptomatic leaves indicated that this factor was statistically significant for seedlings grown at both soil pHs (the probability of larger differences occurring due to chance was less than 0.0001 in both cases). Differences in the percentages of symptomatic leaves among the the four pHs of simulated rain were evaluated using Duncan's mean separation procedure. There were significant differences between

seedlings exposed to pH 5.5 and 3.5 rain treatments, which fall within the pH range measured in ambient rainfall (Table 1).

The effect of growing medium acidity on the percentage of symptomatic leaves was also highly significant. There were more symptomatic leaves on seedlings that had been limed (pH 5.6) than on those that had not been limed (pH 4.6).

Percentages of the surface areas of symptomatic leaves that showed symptoms of infection also were analyzed. The effects of rain acidity and soil acidity could be evaluated simultaneously for this parameter because there was no interaction between the two factors. The results of these analyses were very similar to those for the percentage of symptomatic leaves (Table 2), indicating that the seedlings with the most infected leaves also had the most severely infected leaves.

One must be cautious when extrapolating from a greenhouse or laboratory study to the field. However, these results indicate that there may be a relationship between the acidity of rain and the probability that dogwoods will be infected by Discula sp.

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TABLE 1. Percentages of leaves showing symptoms of dogwood anthracnose after seedlings growing in limed and nonlimed media were exposed to four acidities of simulated rain and inoculated with *Discula* sp. spores

Growing medium pH	pH of simulated rain 2.5	3.5	4.5	5.5
4.6	$15.0_{a,I}$	$4.9_{a,II}$	$3.3_{a,II,III}$	$0.4_{a,III}$
5.6	$53.8_{b,I}$	$23.1_{b,II}$	$26.4_{b,II}$	$0.4_{a,III}$

Note: Within columns, numbers followed by the same letter do not differ significantly at $P \leq 0.05$. Within rows, numbers followed by the roman numeral do not differ significantly at $P \leq 0.05$.

TABLE 2. Average areas of affected leaves showing symptoms of anthracnose after dogwood seedlings growing in limed and nonlimed media were exposed to four acidities of simulated rain and inoculated with Discula sp. spores

Growing medium pH	pH of simulated rain			
	2.5	3.5	4.5	5.5
	- - - - - - - - -Percent of leaf area - - - - - - - - -			
4.6	69 $_{a}$	30 $_{c,d}$	17 $_{d,e}$	2 $_{e}$
5.6	78 $_{a}$	49 $_{b}$	42 $_{b,c}$	1 $_{e}$

Note: Numbers followed by the same letter do not differ significantly at $P \leq 0.05$.

EVALUATION OF CULTURAL TECHNIQUES TO CONTROL DOGWOOD ANTHRACNOSE BENT CREEK, NORTH CAROLINA, 1989

Robert L. Anderson
John L. Knighten
Salley E. Dowsett

Progress Report

EVALUATION OF CULTURAL TECHNIQUES TO CONTROL DOGWOOD ANTHRACNOSE BENT CREEK, NORTH CAROLINA, 1989

BY

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Since dogwood anthracnose was in found the Northeastern United States about 1977, they had an opportunity to evaluate control techniques under Northern growning conditions. In the South, we have a longer growing season and a variety of environmental conditions. Region 8, Forest Pest Management was funded in 1989 to evaluate the control techniques recommended in the Northeast. The recommended control techniques were to:

1) Mulch around the base of the tree to reduce moisture stress and lawn mower damage.
2) Fertilize with a low nitrogen fertilizer.
3) Prune all dead wood and epicormic shoots from the trees.
4) Treat the trees with an insecticide to control dogwood borers.
5) Water during prolonged dry periods
6) Treat the trees with a registered fungicide at 14 day intervals.

Soon after the pilot project started, a number of ornamental dogwoods at the Bent Creek Experimental Forest became infected. We took the opportunity to install a pilot test in June of 1989. Thirty trees were initially examined and an estimation of the percent of limbs infected with the dogwood anthracnose fungus (Discula sp.) was recorded. Five of the trees were cut down because they were judged to be beyond help. Five trees were used as controls and received no treatment. Twenty-two trees were treated with 5-10-5 fertilizer at 4 pounds per diameter inch, reground hardwood mulch was applied out to three feet around the tree and 4 inches deep, all dead wood and epicormic shoots were removed, and a lindane insecticide treatment was applied in July to control the dogwood borers. Fungicides were not used because of the late start in the growing season and water was not added because we had a wet year.

OBSERVATIONS - The trees were treated too late in the growing season to produce useful date in 1989. However, a number of trends were observed:

1) Two trees showed a significant improvement in overall health.
2) Two tree showed moderate improvement in overall health.
3) Fifteen trees showed little or no change.
4) One showed a slight decline in overall health.
5) Two showed a significant decline in overall health.
6) For the control trees:
    a) Three showed little or no change.
    b) One showed a slight improvement.
    c) One showed a major decline in health.

Overall, the treated trees appeared to be more healthy and the treatments did not stimulate the disease.

This study will be expanded and continued in 1990. We will be adding new fertilizer treatments and fungicides. Because of its location, this site could be turned into a demonstration area if the treatments prove to be effective.

AN EVALUATION OF AERIAL PHOTOGRAPHY IN THE SPRING DETECTION OF FLOWERING DOGWOOD, 1989

John L. Knighten
Robert L. Anderson
Walter R. Salazar
Carolyn A. Scott

AN EVALUATION OF AERIAL PHOTOGRAPHY IN THE SPRING DETECTION OF FLOWERING DOGWOOD, 1989

By

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Dogwood anthracnose was found in the Northeastern United States in the late 70's. Since then it has been found down through the Southern Appalachian Mountains and Southern Foothills. A method to monitor the dogwoods over a large forested area like the National Forest was lacking. Remote sensing using different types of aerial photography has been used successfully in the detection of insect and disease problems. The flowering dogwoods (Cornus florida) are very consistent in the production of flowers year after year. This could be used as a way of monitoring the dogwoods over time.

A pilot test to evaluate using aerial photography to detect the flowers of the flowering dogwoods was conducted in the spring of 1989. Areas in North Georgia were photographed using 9 X 9 inch natural color and color infrared films. The photographs were taken at different altitudes to produce scales of 1/5000, 1/3500, and 1/2500.

The flowers of the flowering dogwoods could be detected on both the natural color and the color infrared films. Also, the dogwoods could be seen on all the different scales of the photography. The dogwoods showed up better on the natural color film and because of the amount of area covered by each photograph, the 1/5000 scale was the most practical.

With this method of detection, the flowering dogwoods can be monitored efficiently over a large area. Care must be taken to be sure the photography is done at the peek of production. Also, ground truth checks will need to be a vital part of the project.

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